Teaching Elementary Science With Toys

Preface

It is with great pleasure and pride that CESI presents its seventh Sourcebook, which continues the tradition of providing practical and exciting activities to supplement and enrich your science program. CESI's dedication to stimulating, improving, and coordinating science teaching throughout grades K-8 is evident as you read through and use this publication.

Teaching Elementary Science With Toys: CESI Sourcebook VII offers teachers lots of ideas, using inexpensive materials, which get kids involved in investigations and problem solving. What better way to teach science than through the toys they love to play with? Richard Freyman attributed a great deal if his interest in science to his father who always asked him to look more closely at things, to try figure out why or how they worked, and to one of his early school teachers who encouraged his curiosity, allowing him to explores ideas.

CESI owes a debt of gratitude to Linda Froschauer who selected the topic, contacted authors and reviewers, edited, formatted, and worked with ERIC/SMEAC to produce this quality publication. To Linda, to the cadre of educators who helped with the selection and evaluation process, to the talented and enthusiastic authors, to the artist, and ERIC/SMEAC we say a heartfelt THANK YOU! You have contributed in a very real way to the science learning in our schools.

We are interested in continuing to offer sourcebooks for teachers. We welcome your comments on this book, your ideas for future publications, and offer to author activities.

-Eileen Bengtson
President, CESI 1992-93

Using This Book

A book for teachers, by teachers provides a great richness of possible student experiences. However, like all collections of activities, the student outcomes are dependent on your professional decisions. As you select activities to develop with your students, I suggest you keep a few points in mind concerning the content of this book.

Each activity is comprised two components 1). the science content to be understood and 2). the "sciencing" of the activity .....children doing, recording, expressing ideas, verifying their ideas, participating in further investigatons, working with others, etc. The body of research on student misconceptions is a warning to us to be sure that students are ready to learn and have the correct conceptualization of the content necessary to build upon. Likewise, it's important to be sure students are ready for the next step in the "sciencing" process.

This collection of activities is meant to provide suggestions, food-for-thought. It is impossible to provide over 50 activities in any single book that will totally develop all concepts for all children. Satisfying the needs of your students is, as always, up to you. Some of the activities are stronger in the area of science concept development, others concentrate on science process. All of them can be stretched in many directions to help your students learn and grow.

You will find no grade level indicators on these activities. Many of them can be used K-6 through the manipulation of materials, content level, questioning, and expectations. When making your selections, think of each as a possible introduction, reinforcement, culminating, or assessment activity.

Although many activities provide classroom management suggestions, you will want to use your best strategies for cooperative groups, material organization, record keeping, and safety.

All of these activities were conducted in classrooms with

elementary students. Dual authorship of these activities was encouraged. Each classroom teacher/author was asked to work with a content specialist/author. Hopefully this assures accuracy and classroom effectiveness. That does not mean the activities will all work in your classroom with your students. Try the activities before you do them with students. Look for problems students might encounter, safety hazards, misconceptions that might be reinforced rather than clarified, and extensions to other topics. Change the activity to make it work for you and your students.

The activities in this book include the following information:
Focus: a short description of the science concept or skills developed through the activity and some background information for the teacher.
Challenge: a statement of the activity and a question to be addressed by the student,
Materials: a list of all items needed in order to complete the activity. This does not include materials needed for further challenges.
Resources: sources of materials not readily available.
Safety note: warnings provided by teachers who used these activities and/or reviewers — many of these notes are the law in some states.
Advance preparation: suggested preparation activities for the teacher to accomplish before class time.
Time: an approximation of time needed to complete the basic activity.
Procedure: suggestions to the teacher for conducting the activity with students. This may include organization, introduction, development, and wrap-up.
Further challenges: possible variations, extensions, questions for students.
References: articles or books related to the activity. You will also find a biobliography of all books cited as well as other books that will support these activities at the end of this sourcebook.

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Introduction

Last spring in Connecticut I visited the elementary school I attended in the 1930's. Every third and fourth grade student had made a rubberband-powered model airplane (simple, inexpensive educational kits from the Academy of Model Aeronautics) because they had known of my aviation interests. We all went out to the playground, and after a countdown, 100 models were launched. Amid great excitement, we saw some zoom over the trees, some land on the roof, and, even more exciting to youngsters, some crash dramatically after brief one-second flights. I found it to be a wonderful, inspiring example of the benefits derived from using toys in school. The youngsters were delighted to explore a subject none had tackled before. They did hands-on work to build the models, they tested them and repaired crash damage, they interacted with each other and with teachers and a visitor from the outside world, and they saw a write-up of the unusual event in the newspaper the next day.

I bet a few of those students will now delve more deeply into airplanes as a hobby—and perhaps later as a profession—and that all the youngsters felt a bit more comfortable about exploring new topics, building things, learning by experiment, and enjoying camaraderie with their peers. Ensuing discussions covered connections between bird flight and airplane flight, the migration of birds and butterflies, global challenges of civilization pressures on a fragile ecosystem, and the fact that the world's population had tripled since I was there in third grade. It was a win-win situation, for the children and the world.

Previously, toys were used similarly at all ages. Continual learning is desirable for adults. Throughout our entire lives, formal schooling typically occupies only some four percent of the hours we are awake. Obviously, for continual learning it is the habits and skills we develop at school that are more important than the facts we learn. We adults may not describe a sailboat or a garden or skis or birds or a stamp collection as "toys", but these all have the key element of any definition of toys, namely they have the aspect of play, we are motivated to enjoy being involved with them. They have another key element: they are not a passive spectator sport or indoctrination, rather they lure us away from television into participation that advances physical or mental skills.

For some of us who are especially lucky, even our work is exciting play.

A very young child is an instinctive learning creature, full of curiosity. Watch a two year old in a sandbox with tiny pail and shovel and you will see not only fun and self motivation but also a dramatic learning process in action. A six year old brings the same exuberance to working/playing with hands and mind. Playing with dolls, pulling a wagon, or making soap bubbles is enjoyable learning. Every six year old is a genius. Not only does he/she speak a language (and sometimes two) fluently, with all its subtleties and exceptions, but the six year old also can manipulate and outwit two parents. A tragedy of our educational system is how many of these geniuses are put in circumstances where they lose self esteem, lose the spark of curiosity, and get turned off from education. Toys, games, and experiments can be employed to keep motivating the youngster. School should not all be just fun and games, but hands-on activities can help keep the spark alive. In science particularly, some experiments can be treated as games. The experiments develop understanding and thinking. They have the special virtue that they elicit even if the teacher may not be an expert in science. With the right support tools the teacher can be comfortable in the role of coach, not competing with the student, but helping them develop as far and fast as each child's ability permits.

The most wonderful toys and games that teach are those that the students create themselves. The teacher then has the best possible role—standing back and applauding.

A very valuable science experiment/toy is one that is so interesting that the student wants to share it with family and friends. A prism bending light into colors, a solar-powered model car, creating a cloud by air expansion in a 5 gallon water jar, optical illusion devices demonstrating the human eye's blind spot, counting tree rings, launching a hot air balloon you built yourself from tissue gores, obtaining a cocoon from which a giant moth will emerge, etc. — all are worth showing to others, and in describing them, learning more about them yourself. In our increasingly technological world, every student needs some understanding of technology, and of science as a way of explaining reality and sorting out fact from fiction. The student may not become an engineer or scientist, but will become a voter and global citizen. The human mind, individually and collectively, is the most powerful force on earth. It now controls civilization's future. Motivating and

opening students' minds is simply the most important job in the world.

A few toys stand out in my early childhood memories: a three dimensional puzzle of the Empire State Building, model trains, Erector Set, a little box with a ball that could be maneuvered past obstacles to a high score, and, best of all, the big cardboard boxes in which a stove and refrigerator had been delivered and which could be built into tiny a tiny individual house. In later childhood and adulthood there were more sophisticated toys: bicycles, model airplanes, and eventually even sail planes and airplanes in which I flew. In addition, while raising three sons, there was the opportunity to indulge in a new world of toys for children, including toys more advanced by three decades of technology than the ones of my youth. When I was building and flying those model airplanes at ages eleven through seventeen, I thought I was playing with toys. Now I realize I was actually receiving a unique and wonderful education - that some forty years later helped in achieving human-powered and solar-powered flight, winning aviation's largest prizes, and participating in pioneering electric cars.

In summary, the goal of the U. S. education system should be to turn out one million Benjamin Franklins a year. Ben was always curious, he played, he designed, he experimented, he wrote, he inspired, and he connected his science and technology to the larger issues of society.

-Paul MacCready

Dr. MacCready is the President of AeroVironment Inc. The creativity and inquisitiveness he experienced while playing with toys as a child led him to become an adult with the same type of enthusiasm for learning and playing. He is the inventor of the Gossamer Albatross, Gossamer Condor, and the Solar Challenger....a modern day Ben Franklin.

1 Energy Toys Learning Center

By: Beverley Taylor and Anita Kroger

Focus:

All processes, both physical and biological, involve conversion of energy from one form to another. Toys provide concrete examples of many of these processes. Toys which are battery powered convert chemical energy into many other forms of energy, such as mechanical energy, sound energy and light energy. Many toys use springs or rubber bands to store energy temporarily (often called potential energy) then slowly convert it into kinetic energy as the toy moves. The energy which is stored in the spring originated in the chemical energy in food which the body uses to move muscles which then do work in winding or compressing the spring. Toys such as spring-ups or jumping disks also involve changes in gravitational potential energy as they move up and down. This activity is not meant to be an introduction to energy ideas, but rather to give the students the chance to review energy concepts and apply them to a new situation. Also an excellent lead-in to ways in which humans use and transform energy and energy conservation.

Materials:

Toys which store and release energy.
Some possibilites:
spring-ups
dart guns (rubber tipped)
pull-back cars
jumping disks
any wind-up toy
any battery powered toy
rubber band airplanes

Advance Preparation:

Teacher will need to prepare directions for any unusual toys, blank observation sheets, and an answer booklet.

Challenge:

Students will analyze how a toy works through observing all the various ways in which energy is changed.

Time: About 45 minutes of whole group instruction plus individual student time at the learning center.

Procedure:

1. Develop a question/observation sheet. Include questions such as: Describe in your own words what this toy does. How many kinds of energy do you observe in the operation of this toy? When does this toy have kinetic energy? Where did this energy come from? Was energy stored in this toy? If so, where was it stored? What caused the stored energy to be converted to kinetic energy? Provide space to write additional observations not covered by the questions.

2. Develop an answer booklet for the particular toys you use in your learning center. This might be in the form of a paragraph discussing the energy transformations in each toy or a completed student question sheet for each toy.

3. Introduce the center to students. Explain that over the next week they are to choose three toys from the center, make observations of how they work and complete a question sheet. You may wish to demonstrate any unusual toys at this time and complete the observation/question sheet with the group.

Q Can you change the amount of kinetic energy the toy has from one time to the next?

4. Explain the grading procedure to the students. After they have completed the question sheet, they should get the answer booklet and read what it says about their toy. They should give themselves a grade based on their answers. Their completed question sheet is turned in for your grade or comment.

Q When does the toy have the most kinetic energy? ... the most potential energy?

5. At the end of the time allotted for students to have access to the center, hold a summarizing class discussion with the focus on patterns observed and generalizations which may be made about the energy toys. Each toy should be briefly demonstrated and discussed.

Q Is friction important in the operation of this toy?

An alternate procedure is to divide the class into small groups and assign each group a toy. They will then complete the question sheet for that toy and report back to the class.

Further Challenges:

Bring in other toys that transform energy and explain how they work.

Connections:

Social Studies: Trace energy conversions from the chemical energy in the fuel which runs the electrical generating facility to the end uses of electricity such as heat and light.
Language Arts: Write paragraphs comparing and contrasting two of the energy toys.
Write a persuasive piece encouraging fellow students to use toys whose energy comes from the person using them rather than batteries.

References:

•Gartrell, J.E. and Schafer, L.E. . (1990). *Evidence of Energy.* Washington D.C.: National Science Teachers Association.
•Craig, Annabel and Rosney, Cliff. *The Usborne Science Encyclopedia.* London, England: Usborne Publishing Ltd.

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2 Toys That Change Color

By: Celia A Dornser

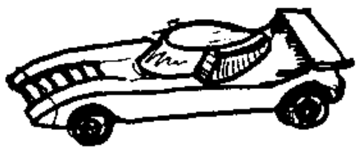
Focus:
The nature of color change toys we use today was discoverd in 1888. An Austrian botanist by the name of Freiderich Reinitfer made the discovery in his work on cholesteric or liquid crystals from plants. These liquid crystals will change their position when heated or cooled. In this process, the liquid crystals change position causing light to be reflected in a different pattern. The result is a variation in color.

Challenge:
Using various toys which incorporate liquid crystals, discover the relative temperatures at which different kinds of liquid crystals change colors.

Time: one class period

Materials:
You will need two of the following:
color changer cars
transformers
liquid crystal sun glasses
mood rings
liquid crystal decals
In addition:
thermometers to take room and object temperatures along with body temperature.
ice
paper towels
hair dryer or other heat source
tongs or tweezers

Sources of materials:
Toy stores
Edmund Scientific
101 East Gloucester Pike
Barington, NJ 08007
Flynn Scientific
P.O. Box 219
Batavia, IL 60510



Procedure:
1. Each student should select two toys which have liquid crystals as part of their construction. They should be picked up with a set of tongs or tweezers to prevent heat transfer.

2. Ask students to give a description about their two objects. The description should include the color of objects before handling and the temperature of the room at this time.

3. Students should record the following information
•Place the toys in hands for approximately 2 minutes. Note any color changes.
•Use a digital thermometer to take body temperature and record it. Some liquid crystals will change color due to body temperature.
•If the toy does not change when held, use a hair dryer to heat it further. Note any change in color with the hair dryer. Place a thermometer in the path of the hair dryer and note the temperature.

6. Do a study of the length of time it takes for the color to change back to its original state after heat is removed (at room temperature).
7. Heat one of the toys again and after it changes color cool it

Q How can the color be changed back to its original state quickly?

directly on a bed of ice. Record the amount of time it takes for this object to change back to its original color.

Further Challenges:

•Order a teaching set of liquid crystal sheets. The set is especially made so that you have a number of different kinds of liquid crystals that will change color at a number of different temperatures. Provide groups of students with a variety of samples to investigate.
•Conduct a product survey. Have students visit toy stores to determine and list products that use liquid crystals.
•Have students create an art project using liquid crystals.

Reference:

Encyclopedia Britannica. (1979). VI: 225.

Q Many machine parts wear because of friction. Friction produces heat energy. How do you think liquid crystal painted parts would save time and money for a company using a large number of machines?

Q What are other uses for liquid crystals?

Q When liquid crystal paints are used to design fancy murals on cars, the designs appear to be moving. Can you explain why?

The Author

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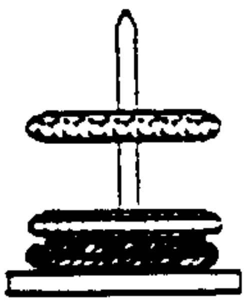
3 Magnetic Acrobats

By: Beverley A. P. Taylor and Anita M. Kroger

Materials :

For each magnetic toy:
3 small donut-shaped magnets
a pencil, straw or dowel rod in the size of the hole in the magnets
a ball of clay at least one inch in diameter
or
1 Magna-Trix™ toy by Tedco, Inc.

Each group of students will need 1 magnetic toy and a ruler



Focus:

Understanding how the magnetic toy mechanism works requires a good understanding of both magnetism and forces. The ring magnets have a North pole on one face and a South pole on the other face. Magnetic poles repel if they are alike and attract if they are different. The size of the force depends on the distance between the magnets. When a magnet appears to "float", the lower magnet is exerting an upward force on the upper magnet of just exactly the right size to cancel out its weight. The greater the weight the smaller the distance must be in order for the magnetic force to be large enough. By Newton's third law, the top magnet must also be pushing down on the bottom magnet with the same size force. Thus, the force exerted by the top magnet on the bottom magnet is the same whether it is laying on top of it or "floating" above it. When a third magnet is added (either touching or "floating"), the bottom magnet must now push up with a force equal to twice the weight of one magnet, so the distance between the lower magnets must get smaller. The middle magnet is also pushing up (repelling) the third magnet.

Challenge:

Can you determine what holds up a floating magnet? Does a magnet still have mass when it is "floating"? If so, how could you measure it?

Time: 30 minutes

Procedure:

1. This is a small group activity. You may give instructions for each part orally or prepare an instruction and question sheet in advance. In the former case, each group would do the experiment and then the class would discuss the results before going on to the next part. In the latter, the small groups could work through the entire activity in a more independent fashion and a summary discussion could be held at the end.

2. Have the students assemble the floating magnets (or use

commercial toys). Make a model by placing the dowel in the clay to form a stand - see illustration.

3. Arrange two magnets on the stand so that one is floating above the other. Push down on the top magnet. Feel the force with which it pushes back on your hand.

4. Using the three magnets make as many different patterns as possible. (Two possibilities are shown.) Get together with another group and see how many patterns you can make using six magnets. Draw all your patterns.

5. Put three magnets on the stand so that two are "floating". Make the top magnet move without touching it.

6. Put two magnets on the stand so that one is floating above the other. What is holding the top magnet up? Measure the distance between the two magnets. What would happen if you put a third one on top so that it floats above the middle one? Would the distance between the first two magnets change? Explain why you think it would or would not. Try it and see what happens.

7. Now take the top magnet off, turn it over and put it back on. Does this change the distance between the bottom and middle magnets.? Have students report the results for numbers 6 and 7 to the class including ideas as to why this happens.

9. Conduct the following demonstration. Set up an equal arm balance. On one side, put the stand with one magnet on it and enough mass on the other side to balance the toy. Ask the students what will happen if you add a second, floating, magnet. Will the balance still be balanced? Be sure to call attention to the fact that the upper magnet does not touch the lower one. After making predictions, put the second magnet on the stand. Many students will be surprised to see the toy side go down. Discuss the idea that the top magnet is pushing down on the bottom magnet with the same amount of force as if it was laying on top of it.

Further Challenges:

What happens if the magnets are set up on a horizontal rod so they can move freely?

Reference:

White, Jack R. (1987). *The Hidden World of Forces.* New York: Dodd, Mead and Company.

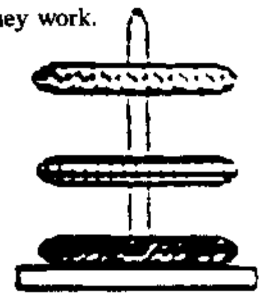
Q What other forces are working on the magnets?

Q Where does this force come from?

Q Can you make this magnet jump off the stand?

Q Can you make a general rule about distance between stacked magnets for any number of magnets?

Q What other toys use magnets? Explain how they work.



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4 Grow Creatures

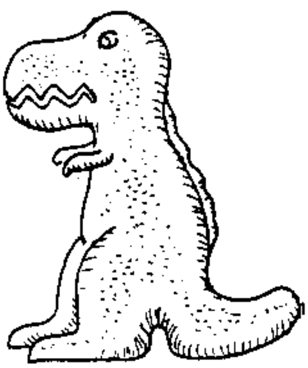
By: Celia Domser

Materials:
Each group of two students will need:
2 Grow Creatures™ (same size)
1 quart jar
Water (enough to fill jar)
Paper towels
Metric ruler
Triple beam balance (capable of measuring to .01 g)
pan

Material Sources:
Sodium Polyacrylate:
Flynn Scientific
P.O. Bob 219
Batavia, IL 60510
Grow Creatures™:
Toy stores

Safety Notes:
Grow Creature™ can irritate the eye.
Wash eyes thoroughly with clear water.
Leave the grow creature in water to prevent mold growth.
Always wash hands when you are finished.

Q What is a way to measure the odd-shaped Grow Creatures™ so that all are similarly measured?



Focus:
Super absorbent chemicals have the ability to pick up liquids allowing their original size to be greatly increased. These chemicals have been used in industry as well in agriculture and our own home. Sodium polyacrylate has been used in toys to make small figures grow causing the original size to increase dramatically.

Challenge:
Which Grow Creature™ will hold the most water?

Time: Two class periods. One period for setting up your material and a second one for completion.

Procedure:
First class period

1. Remove two grow creatures from the package and weigh each within 0.01 gram. Use Grow Creatures™ which are the same shape and size.

2. Measure the length, height and width of your Grow Creatures™.

3. Place one grow creature into each of two containers. Pour tap water into each jar and fill to within one inch of the top. Cover the container to prevent evaporation.

5. If it's possible, check on the Grow Creature™ every hour for several hours to note any size changes. If this is not possible allow 8 to 12 hours or the next class period to complete data.

Second Class Period

6. Note any size, color or texture changes. Remove grow creature and towel dry it so that it is not dripping wet.

7. Place a dry, empty container on a balance and mass it. Add the Grow Creature™ to the pan and mass both together. Subtract the mass of the pan from that of the pan plus grow

creature to determine the current mass of the grow creature.

Further Challenges:

•Shrink your Grow Creature™. Note how long this takes. Does the grow creature shrink to the same size?
•Investigate Grow Creatures™ from different companies. Do they differ? Which companies grow creatures are more absorbant?
Investigate baby diapers and compare which diapers absorb more liquid.
•Graph time for absorption versus gain in mass for Grow Creatures™ and diapers.
•Compare mass of Grow Creature™ to mass of liquid absorbed.

Connections:

Language arts: Write a story or poem about the life of a Grow Creature™.
Technology: Think about how a Grow Creature™ could be used to help people.
Make a drawing of your Grow Creature™ at work helping someone do their job better, enjoying a sport, or in aide to a handicapped person.

Q Is there more than one way to shrink a Grow Creature?

Q What is the ratio of grow creature weight to amount of water absorbed?

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5 Salt Solutions and Grow Creatures

By: Alison Dowd, Tom Runyan, and Jerry Sarquis

Materials:
Each group of students will need:
metric ruler
balance scale (optional)
Grow creature* (small animal-shaped novelty sold in toy stores under a variety of names, e.g., Gro Beast™; advertised to grow to many times its original size when placed in water)
tap water or distilled water or salt water solution
plastic container or wide mouth jar
data table for recording measurements and results
graph paper

Resources:
Accoutrements
Box 30811
Seattle, WA 98103
(206)782-9450
Flinn Scientific
131 Flinn St.
Batavia, IL 60510
(708) 879-6900

Advance Preparation:
Make the salt solutions according to Table 1.

Q Why do you think some diapers are called "super absorbent"?

Q What conditions do you think may affect the super absorber?

Q What would happen if each group measured their creature differently?

Focus:
Super absorbers, found in diapers and grow creatures, are made of "water-loving" (hydrophilic) polymers that can absorb an amount of water equal to many times the original mass. The grow creatures have a second polymer that is "water-hating" (hydrophobic) that forms the framework of the creature enabling it to grow without losing its original shape. Sodium chloride (an ionic substance) interferes with the ability of the polymer to absorb water. As the concentration of sodium chloride increases, the water absorbed by the hydrophilic polymer decreases. As a result, the grow creature in 3.5% salt water has little change while the grow creature in distilled water has the greatest change.

Challenge:
Students will observe the action of the super absorber and speculate on the most effective conditions for absorbing water. Which lab team can grow the largest creature?

Time: 20-40 minutes and overnight follow-up

Procedure:
1. Show students a diaper such as "Ultra Absorbent Pamper". Describe how a fine powder called sodium polyacrylate can be removed from the diaper. Tell the students that the polymer can absorb over 800 times its mass of water under certain conditions and is known as a "super absorber".

2. Give each group of students a grow creature. Explain how it is also made with a super absorber. Have students measure the creature's mass, as well as length, width, and thickness. (This will generate much discussion and a group decision must be made on the appropriate way to make the measurements.)

3. Record measurements in a data table.

4. Assign each group tap or distilled water or a salt water solution (prepared according to the following table).

5. Have students label their plastic container or wide mouth jar with its contents including the concentration for salt solutions, time of day, and date.

6. Place the creatures inside their containers, saving one as a control, and leave undisturbed overnight.

7. On the following day, remove the grow creatures from their solutions, and again measure length, width, thickness and mass. Compare the measurements to those of the control creature.

8. The grow creature may be returned to the appropriate solution for a longer period of time. Measurements can be recorded periodically until no further change occurs.

Q Which is the solvent and which is the solute in the solution you are preparing?

Q What is the concentration of salt in brackish water, urine, the ocean?

Q How does increasing salt concentration affect the growth of the creature?

Assessment:

Have students record data and construct a graph from class findings.
Very young students may actually line up their grow creatures on laminated paper to construct their graph.

Solutions	Salt	Water
0.5% fresh water	2.5 g 1/2 t.	500 mL 3 cups
1% human body fluids	5.0 g 1 t.	500 mL 3 cups
2% brakish water	10.0 g 2 t.	500 mL 3 cups
3.5% ocean water	17.5 g 3 1/2 t.	500 mL 3 cups

Further Challenges:

Try adding the grow creatures to other types of solutions (non-ionic) such as sugar water and compare the results. Does temperature affect the growth of the grow creature? Is it possible to shrink the grow creatures? Do they return to their original size? How long does it take for them to shrink? How have living organisms adapted to living in different saline environments?

Connections:

Encourage students to suggest new uses for super absorbers. Why are super absorbers sold to add to potting soil? Could a super absorber be invented to clean oil spills?

References:

Chem Fax! Publication Numbers 755.10 and 1926, Flinn Scientific.
Harper Encyclopedia of Science
Polymers Link Science and Fun, Marie Sherman, Ursuline Academy, 341 S. Sappington Road, St. Louis, MO 63122.

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6 Flying Saucers

By: Carol Van De Walle

Materials:
Class will need one of each:
Aerobie™
Frisbee, 1 large and 1 small plastic foam disc
fabric disc
other available discs provided by students
trundle wheels, measure tapes, or measuring strings
calculator

Safety Note:
Students should be reminded to watch for others in their paths and to be cautious of flying airfoils.

Advance Preparation:
Prepare a data sheet for each student.

Focus:

Frisbees, Aerobies™, and saucers of other designs and materials can be used for an exciting outdoor activity emphasizing measurement, controlling variables, data collection, and data analysis. These objects are all part of a group called airfoils because they have a top surface that is slightly curved and a bottom surface that is flat. This shape is what produces lift, the same way it does with an airplane as air travels over the wing. You should find that the Aerobie™ flies three to four times the distance of a Frisbee. This is due to the shape of the outer edge, the Aerobie™ has a special lip called the "spoiler". Other factors influence the flight of airfoils, such as angle of release, spin, and wind.

Challenge:

Which type of airfoil will travel the greatest distance?

Time: 3-5 class periods of approximately 40 minutes

Procedure:

Classroom organization: Students work together in small groups collecting data which will be shared with the whole class. Each will have an opportunity to test the different airfoils, observing how they fly as well as distance.

1. Discuss students' experience with each of the different airfoils. Encourage accurate observations.

2. Discuss a "fair test". List variables that must be controlled including method of throwing, angle of release, thrust, and amount of spin. Discuss variables you may not be able to control that may influence the results such as wind speed and direction.

3. Set up a starting line, divide students into groups with one airfoil per group. Airfoils will be rotated between groups as each completes their test.

4. Students should each take a practice throw, observe airfoil

flite and record observations on their data sheet.

5. After all data is collected, in the classroom, students should analyze the flight distances

•Find the average distance thrown for the group.

•Graph this information.

Q Which airfoil flies the greatest distance?

6. Record all group data on a class record sheet (can be placed on an overhead on flip chart, or chalkboard).

•Graph the class information.

•Find the greatest distance thrown for each of the individual airfoils.

Q How can you be sure you have made accurate measurements?

7. Inspect the shape of the airfoils and analyze how this may relate to the flight.

Q What causes results for a single airfoil to differ from another?

Wrap-up: Discuss how the flight of airfoils relate to the flight of an airplane or the shape of a tractor/trailer semi-truck. Discuss any problems that may have arisen with data collection and analysis.

Q What factors, other than shape, contribute to different airfoils behaving differently?

Assessment:

Observe students working independently within a small group -- check for ability to stay on task, share jobs, assist others, accurate measurement and data recording, graphing, etc.

Further Challenges:

•Using the Frisbee and Aerobie™ only, how does the angle of release and spin affect the distance? How do the flight patterns compare when the release is kept the same?

•Use paper plates or foam plates to develop an airfoil. What can you do to the plates to make them fly farther?

Q How can an airfoil be designed to decrease drag/ friction?

Connections:

Technology: Apply the airfoil to transportation and the environmental impact this could have as vehicles use less fuel.

Language Arts: Write an ad for your newly designed airfoil; give it a name; apply for a patent.

References:

Proujan, Carl. (1987). *Science World,* "The Way It Works: Frisbees and Aerobies". May 18, 24-25.

Jamrock, Maureen. (1987). "Phrisbee Physics". Dolton, IL. unpublished workshop.

Herbert, Don. (1980). *Mr. Wizard's Supermarket Science.* New York: Random House.

Weiss, Stephen. (1984). *Wings and Things.* New York: St. Martin's Press.

The Author

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7 Top-ing a Colorful Lesson

By: William J. Boone

Focus:

Toy tops can be 1) constructed out of inexpensive materials, 2) purchased easily and 3) used to demonstrate a variety of science topics.

Materials :

variety of store purchased tops
sharpened pencils
clay
cellophane tape
paper plates of various quality and thickness
colored markers

Challenge:

Students will construct a number of tops. They will learn what effects the spin, and stability of a top. In addition they will begin to learn how colors combine.

Time: 45 minutes to 1 hour and 15 minutes

Procedure:

1. Present students with a variety of purchased tops. These can be purchased at local discount stores. Ask students to explore with the tops. Tell them that they should note differences in the design of the tops and "spin quality."

Q What do you do to make a top spin?

Q How can you make a top spin faster?

Q How do the tops differ?

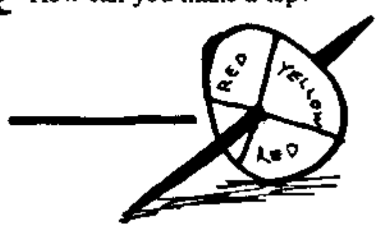
Q How are the tops alike?

2. After students have explored with the tops, ask them to write their observation on the board. Your students will probably have a wealth of observations, but some of the key factors you may want to help them note are each of the top's mass, width, height, spindle width, and construction material. Students may notice that the tops which spin closer to the ground seem to be easier to spin and stay upright (with out wobbling) for a longer period of time. This has to do with "center of mass." Perhaps the best way to explain this is to have students note that a race car, which is low to the ground, is less likely to tip over than a tall van which is near the ground. The same is true of tops!

Q What could be some reasons why certain tops spin better than others?

3. Now ask student groups how they might build their own tops. Let students brainstorm this question for a while. After each group has devised a technique that could be used for the construction of tops, allow all students to share their ideas.

Q How can you make a top?



4. Have students carefully place a pencil through the center of a plate. The pencil can be anchored in place with tape, or a small amount of clay.

5. Each student in every group will create a top. Ask the student groups to evaluate the tops they have designed and built. Consider these factors:
•position of plate on pencil
•grip on pencil when initially spun
•size of components.

6. To learn more about color blending, ask students to carefully use crayons, or markers to color parts of their tops. This should be done with plate on a flat surface before placing it on the pencil. First, have students color "pie piece" wedges on the top with just two colors. They can later create tops with many colors. After students have colored the tops, have them list on the board the colors they have marked, and ask them to predict the color they will see when the top is spun.

7. Share group observations. Which groups predicted correctly? Have groups explain why they made specific predictions.

Further Challenges:

A television set can be used to "slow down" the spin of a top. Just plug in a television and turn off the lights. Then take a top and spin it so that the light from the television hits the top's surface. You will notice that the television's light enables you to see the non-combined colors of the top. This strobe effect is the result of the flashing images on a TV screen.

Connections:

Art: If there is a special holiday approaching, students can develop new tops that involve holiday colors.
Technology: By spinning a gyroscope students will be able to see that it does not wobble very easily. Point out that because the gyroscope is stable, it is used as a device in navigation.
Language Arts: Many books contain stories about tops and color blending. Have students share their favorites.

References:

Caney, Steven. (1972). *Steven Caney's Toy Book.* New York: Workman Press.
Malone, Mark (ed). (1992). *CESI File Sheets Volume 2.* Colorado Springs, CO: Council For Elementary Sience International.
Radford, Don. (1981). *Science From Toys: Science 5/13.* New York: MacDonald Educational.

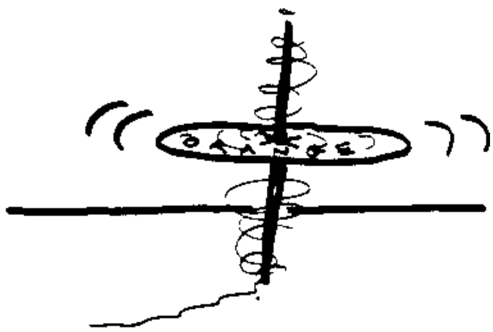
Q What are the characteristics of a good top?

Q What is the relationship between the position of the plate on the pencil and the stability of the top?

Q What can be done to the pencil to provide a better grip?

Q Can you predict the shape of the image that is produced when you spin the top?

Q What designs, other than "pie pieces", could be marked on the top?



Q What other uses are there for tops?

The Author

William J. Boone is the Elementary Science Coordinator in the School of Education at Indiana University, Bloomington, IN.

8 Toy Catalogue

By: Gerald Wm. Foster and Anne Marie Fries

Materials:
a collection of toys for the class which can be obtained by students bringing in toys of their own or by the teacher collecting them through garage sales and donations.
colored pencils
a booklet for each student made from unlined paper

Advance preparation:
Send a letter home asking parents to lend the class toys that move through a variety of energy sources (wind-up, electrical, air, water, sand, gears, gravity, magnets, etc.) or exhibit scientific principles (magnetism, lenses, mirrors, light, etc.). Toys such as Barbie dolls, basic boardgames, and stuffed animals would not fulfill the needs.

Focus:
Toys are the perfect resource to explore concepts of motion, force, energy, heat, sound, light, magnetism, electricity, and other basic scientific principles that are at work in our everyday world. Children are naturally curious about work in our everyday world and toys. By using toys and having children explore how they work, they will observe first hand the basic principles of motion, force, and energy. Students can then classify toys according to how they work.

Challenge:
We will be putting together a catalogue of toys that operate on a scientific principle. How many categories of toys do we have in our collection? Carefully explore what makes these toys work and then develop a list of categories in which to classify them.

Time: two or three 30-40 minute classes

Procedure:
1. Set the toys out around the room. Students can work in small cooperative groups or they may work individually.

2. Students explore as many of the toys as time allows in the first class. Students make a list of all the different basic scientific principles that explain how the toys work.
For younger students this could be a simple list such as water, air, electricity, gears, lenses, mirrors, gravity, magnets, etc. For older students it could be more specific to the scientific concept such as gravitational pull, center of gravity, density, high and low air pressure, law of magnets (opposites attract and likes repel), buoyancy, etc. This will be determined by the science curriculum content and what the students have already experienced.

3. At the end of the first session, a list of categories should be brainstormed by the class and placed on the chalkboard. You may want to limit the number of categories, making students really look for toys that work on the same principle but are presented in a slightly different form. This will be determined

by the age of the students and the types of toys in your collection. As the class ends, there should be some agreement on the list of categories.

4. Students can design a cover for their toy booklet individually or you can have students submit covers to be selected by the class through a vote and then copied to be on the cover of the booklets you have made. Older students can fold and staple their own booklets.

5. Students go through the entire collection of toys, classify all toys, and draw pictures of the toys using colored pencils on the appropriate pages.

Advance Preparation-session 2:
Prepare a booklet of blank paper for each student. On each page of the booklet write the name of a category (from step #3). This booklet can be made by stacking several sheets of 8 x 10 in. or 8 1/2 x 11 in. blank paper (ditto or Xerox™ paper works fine). Fold the stack of paper in half to form a booklet that is 8 x 5 or 9 1/2 x 5.5 inches and then staple along the fold.

Q Do some toys fit into more than one category?

Assessment:

The booklets will be used to assess how well the students understand the basic idea of classification as well as the basic scientific principles that explain how the toys work. A discussion by the class will also be helpful. Each student could select one toy to explain to the entire class.

Further Challenges:

•Go through toy catalogues and use pictures to cut and paste into the toy catalogue you have created to add to the collection.
•Have each student or pairs of students invent a toy. First design the toy on paper. Determine a list of materials and amounts of each material that will be needed to make the toy. Find out how much the materials will cost to determine how much the toy will cost to make. Determine how much profit the class will make on each toy in order to set the price of the toy. Create a toy catalogue of the toys invented.

Connections:

Math: problems could be created to use the data from the toy catalogues, if prices are listed. Use retail catalogues for more math problems.

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9 Tracks

By: Gerald Wm. Foster and Anne Marie Fries

Materials:
a collection of toy vehicles, dolls, and action figures.
a ball of clay for each student
tempera paint
big sheet of painting paper
hand lenses
metric rulers

Focus:
Making observations, inferences and predictions are basic science process skills. A study of tracks provides the perfect opportunity to work on these skills. This is usually a part of every unit on animals but can also be explored when learning about how to look for and interpret clues in our natural world as well as developing the process and steps involved in experimentation and problem solving. Basic classification skills can also be developed with a study of tracks.

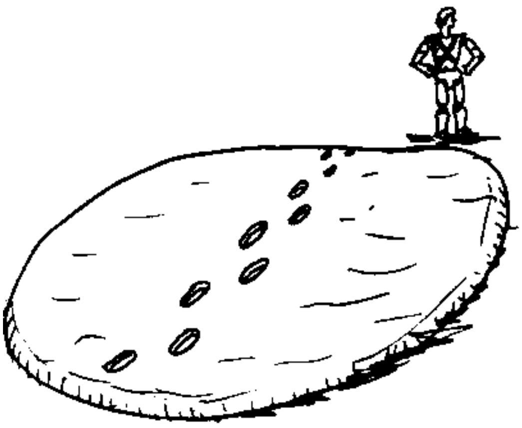
Challenge:
What kind of tracks will these toys make?

Time: one or two 30 - 40 minute classes

Procedure:
1. Give each student a ball of clay. Tell them to flatten the clay into a "pancake."

2. Give each group a set of toy vehicles. Tell them to make tracks with the toys in the clay.

3. Observe the tracks that each toy makes very carefully. Use the hand lens to study the tracks. Instruct the students that they will need to roll the clay into a ball and make a new pancake when it is full of tracks or devise a system of smoothing over the tracks for a smooth surface.



4. Have each student make tracks with one toy and then pair up the students, having them guess which toy made their partner's tracks. Or the teacher can prepare a set of tracks before class and present them to the students for them to guess which vehicle made the tracks.

Q Which tracks show more detail?

5. Repeat the process with paint. Dip the bottom of the toy in a small pool of paint and make tracks on the paper. How do the tracks compare to the ones made in the clay?

6. Measure the span of the tracks. Can you change the trail of the tracks as they move along the paper (closer together like

running, further apart as in walking, zig-zag, etc.)?

7. The students or the teacher can prepare a set of tracks, let them dry and then cut them apart. Classify the tracks. Discuss the different ways the tracks can be classified into groups.

Q Into how many different groups can the tracks be placed?

8. Have the students name the toys that made the tracks based upon their experience with the toys, not by actually looking at the toys. Then check their prediction/inferences with the toys. With older students it is interesting to start this entire lesson with teacher prepared cut out paint tracks or without seeing the toys. Collect their predictions. Then let them explore the toys and their tracks. As an ending activity, pass back their predictions. Do they want to change any of their answers? Why? What is the difference between the predictions they have just made and the predictions that they made before we began our study?

Assessment:

As the students are working, circulate among them and observe them in action. Ask questions such as those listed above to assess their ability to make observations and inferences. The final part of the activity, making an inference and predicting which toy made which track, can also be used for assessment purposes.

Further Challenges:

•Go outside and look for tracks. This is especially good to do in the winter time when you can find tire tracks, sled tracks, animal tracks, human tracks, tracks made by things being dragged, etc. or in spring and summer along creek beds. Draw the tracks and make an inference as to what they think made the track.

•Explore animal locomotion with the tracks. How were the tracks made. How does this animal move? Demonstrate.

•Use a book of animal tracks or borrow animal track stamps for a resource such as the Museum of Natural History. Make your own stamps by carving the shape of the foot into a potato half or cutting out a sponge. Classify the tracks (digital, hoofed, claws, number of toes, etc.). Identify the animal by its track using a key.

Q Are there any clues as to how old the track is?

Q How do the prints compare in size?

Connections:

Language arts: Have the students create track stories with the paint and toys or animal stamps. Write the story to be displayed with the track picture.

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10 Altered States of Matter

By: Mary E. Tremper

Focus:

Matter is classified into three states, solid, liquid or gas. All solids have form. They also have hardness and rigidity, or the ability to oppose a change of shape. Liquids have no shape of their own, but they have the ability to flow. They take the shape of the container in which they are placed. For some substances there is no sharp distinction between their solid and liquid phases. One such substance is Silly Putty™.

Materials:

Each group of 3-4 students will need:
1 egg of Silly Putty
Celsius thermometer
meter stick
400 mL glass beaker
cup warmer
1 pair of tongs
science logs
pencils

Safety Note:

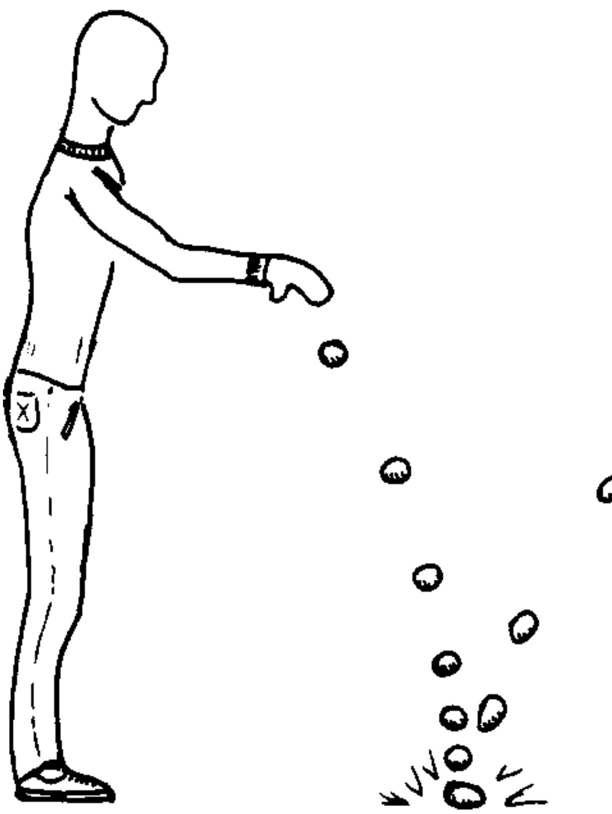
The liquid will warm to 50-60 degrees C. Warn students to be cautious around any hot liquid.

Challenge:

Students will conduct a scientific investigation to determine how different temperatures change Silly Putty™. Bounce height will be used to measure differences. How do you think temperature changes will affect Silly Putty™?

Time: 45 -50 minutes

Procedure:



1. Students spend 15 minutes in initial exploration with Silly Putty™.

2. Discuss, describe and draw Silly Putty™ in logs.

3. Record room temperature in logs.

4. Roll Silly Putty™ into a ball shape. Place meter stick in vertical position on table top (zero end down). As other group members watch, students take turns dropping the Silly Putty™ ball from 30 cm. (Since the bounce is quick, students can practice observing the bounce). Each group records 4 bounce heights.

5. Each group places their Silly Putty™ ball in a beaker with a thermometer. The beaker is then placed on a cup warmer. Record time it takes for the Silly Putty™ to become a liquid. (This takes about 15-20 minutes).

6. While the putty is heating:
•Students observe and discuss the changes in the Silly Putty as it is heated,

•take temperature readings as the mercury rises,
•draw observations in their logs.

8. When Silly Putty™ reaches 60 degrees C, record time in logs. Students then use tongs and attempt to remove the "melted" Silly Putty™. Compare group data.

9. If students are successful in removing the heated Silly Putty™, they can then drop it from 30 cm, and record the bounce height.

Q What effect does heat have on the bounce height of Silly Putty™?

10. Students write and draw about heated Silly Putty in their logs. Have students use calculators to find the average bounce heights for room temperature and heated Silly Putty™. Graph results.

Further Challenges:

•Freeze Silly Putty™. Place the putty ball and a thermometer in a plastic zip close bag, and place this in the school freezer, or an ice filled cooler. Predict what effect freezing will have on the bounce height of Silly Putty™. After several hours, bounce the frozen putty, and find the average bounce height.
•Make homemade silly putty by mixing 2 parts white glue and 1 part liquid starch. This must be stored in an air tight container.
•Locate matter in your everyday environment that are affected by heating and cooling. Discuss the different ways matter can be affected by heating and cooling.

Connections:

Research skills: Silly Putty™ is a non Newtonian fluid. Find out more information about Sir Isaac Newton.
Research information about Silly Putty™.
Silly Putty™ is a silicon product. Silicon isused for many items including body replacement parts. Look up other uses for silicon.

References:

Hann, Judith. (1991). *How Science Works.* Pleasantville, NY: Reader's Digest Association, Inc. 14-16.
Seuss, Dr. (1949). *Bartholomew and the Oobleck.* New York: Random House.

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Mary E. Tremper is a teacher at Seminole Heights Elementary School in Tampa, FL.

11 Balloon Ball

By: Gerald Wm. Foster and Anne Marie Fries

Materials:
Each child will need a minimum of 3 different sizes and shapes of balloons. They will also need enough newspaper, aluminum foil, cloth, and other type of materials for wrapping around a balloon. Glue may be required in some cases to attach the material to the balloon.
Water, sand, and other types of materials can be used to put inside an inflated balloon to change its center of gravity.
Tub of water
A party balloon pump can be used to inflate balloons if you do not want children blowing them up with their mouths.

Q Why were you able to predict some of the actions of the balloon?

Q Why was it more difficult to predict some of the actions of the balloon with the added covering?

Focus:
By covering the balloon with different materials, the weight can be changed; however, the volume of the balloon remains the same. In this activity children not only are testing weight (gravitational pull) and center of gravity but also how different surfaces (friction) affect the motion of a balloon. The balloon's elasticity is also affected when it is covered with different materials. The activity also allows children to experience controlling and changing variables and collecting data from these changes.

Challenge:
Can you predict the behavior of an inflated balloon when you throw, roll, or drop it when it is wrapped with another type of material?

Time: 45 minutes

Procedure:
1. Pair students. They will need a partner to help with observations and perform different kinds of actions on the balloon.

2. Begin with a 3-5 inch round balloon, inflated, and tied shut. Move the balloon in a variety of ways such as:
•roll it across the floor,
•throw it straight up in the air,
• drop it from a given height,
•toss it to a partner, and
•push or roll it across water in a tub. Predict what the balloon will do in each case and record results.

3. Wrap the inflated balloon with a single layer of aluminum foil. Make sure the aluminum foil is smooth as possible and doesn't overlap at its edges. (Hint: it may be easier to put on several smaller pieces and attaching them with a small drop of glue rather than one big piece.) Repeat the procedures in number 2.

Wrap-up: Using the same size and shape balloon, how did the

balloon movement change? What do you think will happen with cloth? Paper? Other materials?

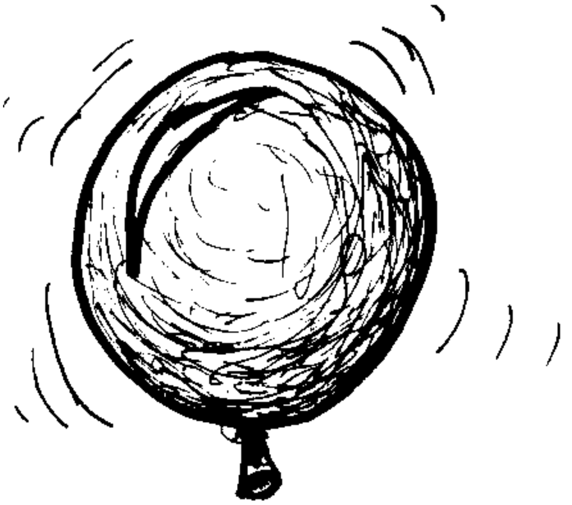
Q What other kinds of variables might affect the motion of the balloon?

Further Challenges:

•Try wrapping the balloon with different types of materials such as newspaper, cloth, saran wrap, and other materials that students suggest. Please note: the cloth may have to be sewn into a ball shape first and then inflate the balloon inside.
•Try different thicknesses of the same or different materials.
•Try different combinations of materials to cover a balloon.
•Try different sizes and shapes of balloons with the same type of wrappings.
•Add material to the inside of covered balloons to change the center of gravity. Water, cereal, sand, etc. can be added to a deflated balloon. It can then be inflated, tied, and covered with a material.
• What happens to the shape of the material covering material if you use a pin to pop the balloon?

Connections:

Math: Students can calculate the mass of balloons before and after covering them as well as when they add material to the inside. They can also measure balloons' circumferences for each size and shape.
Arts: Balloons can be moved to music or decorated.
Language arts: Students can write stories about their balloons and read about how hot air balloons are flown.



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12 Rig-a-Jig: Challenging Machines

By: Mel Fuller

Materials:
the whole class will need:
Rig-A-Jig™ Classroom Set
meter sticks or rulers
tennis balls
small sacks of rocks
boards for slanted inclines
challenge cards

Source:
Rig-A-Jig™ Classroom Set is available from:
Rig-A-Jig Dept. 192
210 West State Street
Geneva, IL 60134
1000 piece set $38.50
430 piece set $20.00

Advance Preparation:
Determine how the challenge cards will be distributed and prepare a set for your class (see step #2 for suggestions).

Focus:
Simple mechanics involves moving parts of a machine. A machine makes work easier by changing the distance or direction of a force. The six simple machines which may be used to do work are levers, pulleys, wheels and axles, inclined planes, screws, and wedges. Compound machines are made of two or more of the simple machines.

Challenge:
Students will design or construct models that demonstrate the six different simple machines from Rig-A-Jig pieces, demonstrate and explain how they work.

Time: 45 to 50 minutes

Procedure:
Classroom management:
This activity is meant to serve as a culmination to a unit on simple machines. The entire activity can be used as a means of summative assessment or can be used as a lead-in to complex machines and more advanced physics concepts.

I. Pre-designed Challenges:
1. Divide the Rig-A-Jig pieces equally among the individual students or teams of students. These can be stored in individual cartons or plastic bags. Have the students examine the pieces and the different ways the pieces fit together.

2. The challenges may be conducted for individual students or teams of students. Give each student or team a "Challenge Card" on which is printed the name and task for a device. The same challenge may be given to all students at once, or different challenges may be assigned to different teams.

From your set of Rig-A-Jig™ pieces...
•design a windmill at least 25 centimeters high.
•design a four-wheeled wagon that will carry a tennis ball.
•design a wheelbarrow that will carry a sack of rocks.
•design a vehicle that will move down a slanted board in less than five seconds.

•design a device in which a marble can roll from top to bottom in less than five seconds.
•design a device with a flat platform on top, at least 30 centimeters tall, and with wheels on the support legs.

3. Have each student or team display their creation and describe how it works pointing out the simple machines used in their designs.

Q How many simple machines are in a single design?

II. Inventions
1. Give the students or teams of students the sets of Rig-A-Jig pieces.

2. Have the students or teams invent a machine with a special purpose.

Q Can you solve a problem with a Rig-A-Jig machine?

3. Set a time limit for finishing the design.

4. Have students or teams display and describe their invention, but have the other students try to guess its purpose or function. Have student teams point out the simple machines used in their designs.

5. Display these inventions in the classroom. Have students-judges from other classes observe the inventions and select the "Most Creative", "Most Useful" or "Most Unusual" designs.

Further Challenges:
•In addition to the Rig-A-Jig pieces, use string, rubber bands, balloons, or wire. Design devices which will move utilizing other energy sources. Go outside to a flat surface area or to the school cafeteria or gym and conduct surface races with your devices.
•Collect pictures from magazines and catalogs of mechanical devices that are similar to those you designed. Label the simple machines involved.
•Invite an auto mechanic, clock repair person, or a mechanical engineer to your class to talk about their careers and the training required for these careers.

References:
Blough, G., and J. Schwartz. (1990). *Elementary School Science and How To Teach it.* Fort Worth: Holt, Rinehart and Winston.

The Author
Mel Fuller is a professor of Science Education at the University of Arkansas at Little Rock.

13 Classroom Speed Trap

By: Jan Woerner

Materials:
Apple IIe, II+, or IIc
Science Toolkit™: Master module
Science Toolkit™: Module 1 Speed and Motion
Software disks for both modules
Interface Box (connects computer to experiment through the game or joystick port)
2 photocells (one comes with each module)
balloons
toy car (comes with Module 1)
Speed Trap (photocell stand - comes with Module 1)
light source (flashlights)
ruler or meter stick
string
masking tape

Resources:
User's Manual and Experiment Guide to Science Toolkit: Module 1: Speed and Motion and *User's Manual and Experiment Guide, Science Toolkit: Master Module.* Broderbund Software, 17 Paul Drive, San Rafael, CA 94903-2101.

Focus:

Speed is a measure of how far an object travels in a given period of time. The energy to move the car described below comes from jet propulsion. The pressurized gases inside the balloon shoot backward through the small opening, causing an equal and opposite reaction. The car is propelled forward past two photocells. The time it takes the car to pass between the photocells is measured and the speed is then determined by the computer. How well the car moves depends on the design of the car, the surface that it is placed on, how much air is in the balloon, and other factors. One of the forces acting on the car is the "push" which comes from the balloon. Friction, a force which acts in the opposite direction of the car movement, also affects the cars' speed. Friction works to slow down the car.

Challenge:

How fast will a balloon powered car travel? What variables affect this speed? Does the size or shape of the balloon make a difference? Does the weight of the car make a difference? Does the surface on which the car travels make a difference?

Time: 1 class period for familiarization and initial trials, including developing a scientific investigation; 1 class period for each investigation performed.

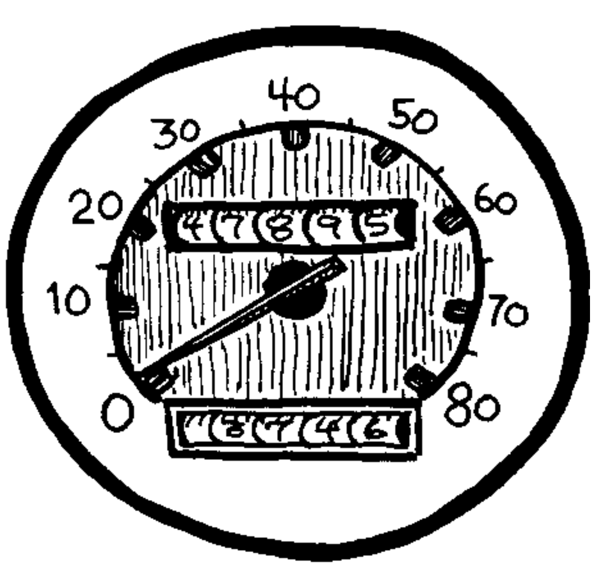
Procedure:

Classroom organization: The class may be organized into groups of 3, but each group needs a computer and both Science Toolkit™ modules with hardware and software. To gain familiarization, the introduction and initial trials will need to be whole class instruction. After students are familiar with the operation of the program and have designed a scientific investigation, you can proceed with whole class trials or allow small study groups of about 3 students to work individually at a learning center.

After each small group has completed the investigation, teams can compare their results.

Set up a track on a table or the floor. The distance the car usually goes is a meter or two; it may go farther as you adjust the variables. The investigation requires a flat surface without

obstruction near the computer on which the car can travel. This flat surface must be adjacent to the computer because the cords which connect the computer, interface box, and photocells total less than 2 meters.



Introduction: Assemble the car, blow up the balloon, place the car and balloon on a flat, easily observed surface, and let the balloon-powered car go. How far does it go? How fast is it going? What things might affect the speed of the car? How can we determine the distance and speed? Students' answers can be used as a basis for the investigation. This is a good investigation for testing one variable at a time, and students will have lots of ideas of how to proceed. Students need to construct their own hypotheses about what causes the car to move, and what things affect the speed of the car.

Development of activity:

1. Both teacher and students will need to be familiar with the procedures involved in running the Science Toolkit™: Master Module.

2. Install the interface box into the joystick port of the computer and attach two photocells (one is included with each module) to the interface box sockets C and D. Assemble the Speed Trap (photocell stand). This stand places the photocells 15 cm (6 inches) apart. The software is calibrated for that distance, but can be changed.

3. Assemble the balloon-powered car. This is a car built from interlocking plastic pieces with a hook for holding the balloon. The balloon is blown up and attached. The car and balloon are released, and the car moves forward as the balloon disgorges its air.

4. Boot up the computer with the Master Module disk and select "Other Tools." After the prompt, insert the Speed and motion Module disk and select "Speedometer" from the Tools Menu. Set up the program so that the timer will start when the car goes by the first photocell and stops when the car goes by the second one. The speed between the two points (in metric and English units) and the time elapsed are shown on the screen. Students will need to try this step several times in order to see what is happening on the screen and what is happening with the car. You may need to adjust the position of the Speed Trap so the car doesn't fall off the table. Once students understand the operation, they can begin collecting data. For each trial, the balloon must be blown up to the same

Resources:
The User's Guide and Experiment Manual provide all necessary directions. If you do not own the module and wish to purchase it, obtain the School Edition since it comes with a Teacher's Guide and the temperature experiments will work at higher temperatures than the public version of the program. The Science Toolkit™ Master Module program disk contains several tools which can also be used for various experiments. This disk will direct you to select other tools from your Speed and Motion disk.

Safety Notes:
Be sure you can identify your balloon since you only blow up your own!
Do not put any of the sensory probes into your eyes, ears, nose, mouth, or other parts of the body. Do not twist the probes. Do not put the probes or the interface box into scalding water or organic solvents, such as cleaning fluid. Do not put anything into the sockets except the probes which are designed to go into them. Do not allow water or other liquids to come into contact with the interface box or the computer.

Q How can you be sure you are blowing up the balloon to the same size each time?

size. This can be checked with a tape measure or a string. Be sure to hold the nozzle of the balloon firmly until you are ready to release the car so that you do not lose any air until then.

5. Repeat the investigation using the photocells to record the speed of the car (see sample table).

Distance from Start to photocell #1	Time from photocell #1 to photocell #2	speed of the car between photocells
10 cm	.33 sec	45.5 cm/sec
20 cm	......	.....
.....	......	.....
1 meter	car stopped	0

Q How can you make the surface even "slicker"?

Students can graph the results from the data table when the investigation is completed, with the distance from photocell #1 on the horizontal axis and the speed of the car on the vertical axis. Repeat this investigation for distances from 10 cm to 1 meter and record the results. What do students notice about the speed of the car?

6. Students can add masses to the car to see if more mass helps or hinder the speed. Pennies balance easily on the plastic pieces, allowing for easily placed and reasonably identical masses. Repeat the same investigation.

Q At what point does the car travel the fastest? Is the balloon inflated, deflated, or in-between at that time?

7. Return the car to its original mass, and change the surface on which it will travel. Construction paper, sand paper, aluminum foil, carpet etc. might be surfaces the students would suggest.

Q What factors cause the car to speed up (accelerate)?..to decelerate?

8. As you blow up the balloon over and over, it begins to lose its elasticity. Several similar balloons may be needed to give you relatively similar pushes.

Wrap-up: When each part of the investigation is completed, have the class (or small groups) report their results. Record the speeds on the chalk board or overhead for each group and compare the results. Have them average the speed for each distance. What they should notice is that the car's speed is not constant over the track. If students investigate the effect of mass or the effect of different surfaces, they can compare these results to the first investigation.

Assessment:

Students should construct their own hypotheses about what makes the car go, what effects the speed at which the car can travel, or what is the best size for the air-filled balloon. Assessment should include the student's ability to design a "fair" experiment to test a stated hypothesis and to present data to support the conclusion.

Further Challenges:

This investigation can be done with students' own toy cars. The cars must be large enough to cut off the light to the photocell. An inclined plane can be constructed, and students could power the cars by gravity as the car runs down the slope. You can build your own photocell stand and place the photocells farther apart as long as you enter the new distance into the software. The software has an easy prompt for this. There are other programs on the market which will allow you to do the same thing, or you can build your own interface device and write your own program; however, the Science Toolkit™ is an easy microcomputer-based laboratory for elementary children to operate.

Connections:

Technology: Design a fast balsa wood car. This car could be a blueprint, or students could build models and test them. Mathematics: Averaging and graphing can be an important part of the comparison of the data collected. The mathematics of speed and acceleration can be studied as well.

References:

User's Manual and Experiment Guide to Science Toolkit: Module 1: Speed and Motion. San Rafael, CA: Broderbund Software.

The Author
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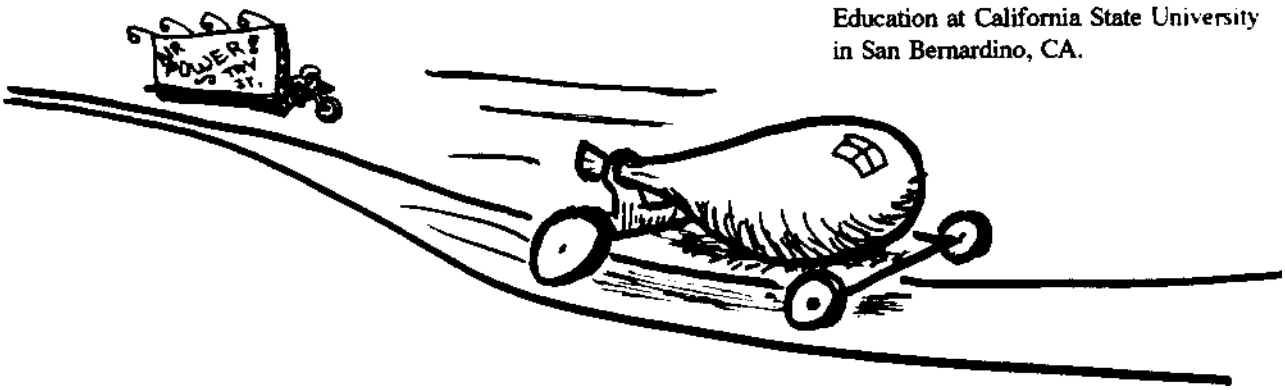


14 Born to Roll

By: Edward L. Shaw Jr. and Robert L. Doan

Focus:

The mass of an object will stay the same but its weight will vary according to the pull of gravity. Heavier objects have a greater gravitational pull. Newton's first law of motion states that a body that is at rest will remain at rest unless some force starts it moving and the object will continue in motion until another force acts upon the object. This law is affected by the inertia of the object which is determined by the mass of the object. Gravity also has an affect on the object. Newton's law of gravitation states that every bodyin the universe attracts or pulls on every other body. The heavier the body (object) the greater the pull of gravity upon it.

Materials:

Each group of two or more students will need:
2 average-sized smooth marbles
2 large-sized smooth marbles
ramp made from 2 mini blind slats, cradled for strength
ramp made with 3 or more mini blind slats, cradled for strenth
contact cement for the slats.
1 metric measuring tape for determining length
a long flat surface, such as a hallway without carpet
chalk or masking tape
several identical books to be used as supports for the ramps
pen and paper

Safety Note:

CAUTION should be used with the contact cement.

Challenge:

Students will test the affect of mass on the distance a marble will travel by rolling marbles down an inclined plane.
Which marble will roll faster? Will the weight of the marble affect the distance the marble will roll?

Time: 45 to 60 minutes

Procedure:

1. Glue the mini blind slats together using the contact cement. Two slats are required for a light marble while three or four may be required for a heavy marble. Allow to dry for 48 hours.

2. Place two of the ramps side-by-side near the end of a long flat hallway. Test the hallway before the activity to be sure it is flat. Make a starting line with chalk or masking tape on the floor. The lower end of the ramps should be on the starting line.

3. On one ramp measure 20 centimeters (cm.) and mark with the chalk or tape. Measure the other ramp to 10 cm. and mark it. This will be known as the "distance of release" during the experiment. Place the ramps on the floor. Place the same number of books under one end of each ramp to create an angle that will be the same for each ramp.

4. Place and hold a marble at the starting points on each of the ramps. Release them simultaneously. Allow them to roll until they stop. Measure the distance using the metric measuring device. Record answers for comparisons. Now switch ramps with the marbles and repeat the experiment. Are the results the same?

Q Which one rolled further?

5. Alter the "distance of release" on each ramp (example: 20 and 30 cm.; 30 and 40 cm.; 40 and 50 cm., etc.). Repeat step 4 and measure/record the results. Do the results differ from the first experiments?

Q Is there a relationship between "distance of release" and distance a marble travels?

6. Use 2 marbles of differing mass (ie: glass, wood, metal). Have students predict the distance each will travel. Repeat the activity in #4. Are the distances the same for both marbles?

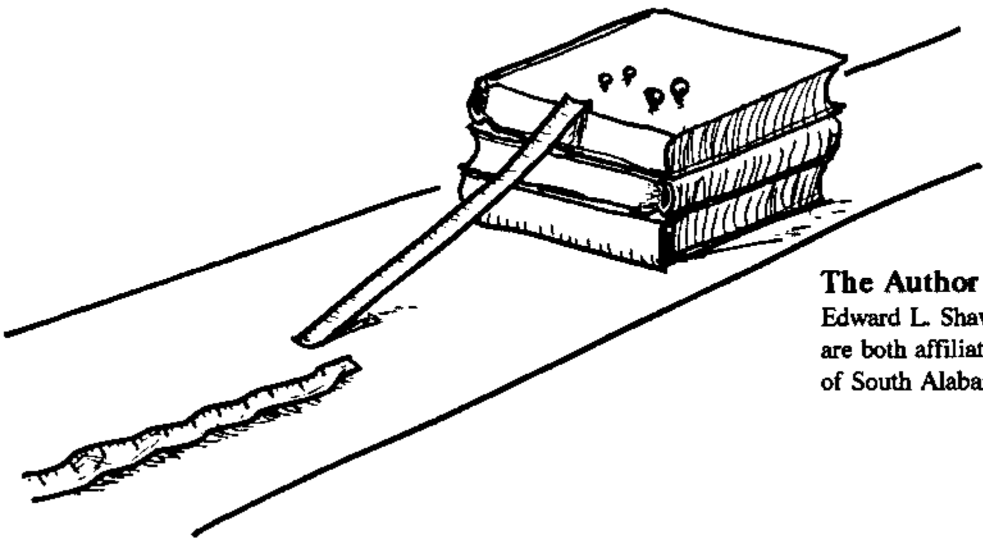
Q What is the relationship between the mass of the marbles and the distance traveled?

Further Challenges:

•Students can try other variables using the ramps.
What is the effect on the distance a marble will travel using two marbles that are not the same size?
What is the effect on the distance traveled if the ramp is not smooth?....if the floor is not smooth?
•Have students, with their parents or guardian, construct ramps at home. They can then test other objects to see how far they roll. They can use oranges, tennis balls, golf balls, hand balls or similar items for their experiment.

References:

Victor, E. (1989). *Science for Elementary School.* New York: MacMillan.



The Author
Edward L. Shaw and Robert L. Doan are both affiliated with the University of South Alabama, Mobile, AL.

15 Color - Change Markers: A Study of Acids and Base

By: John P. Williams, Jo Parkey and Karen Schunk

Materials:
Each group of three or more students will need:
Color-change pens
small open container
ammonia
small open container
vinegar
2 cotton swabs
1 sheet white paper
1 strip litmus paper (or other acid-base indicator) strips

Safety Note:
Students should wear goggles when using ammonia and vinegar. You may also want to dilute these liquids as an extra safety precaution.

Q What food or household substances exhibit characteristic taste or feel?

Q What color changes occured for each marker?

Q Have the colors changed? If so, how?

Q Are the color changes reversible?

Focus:
For centuries acids and bases have been recognized by such characteristic properties as taste (sour for acids as in citrus fruits and bitter for bases such as of caffeine), feel (soapy for bases, such as cleaners containing ammonia), and ability to change the color of certain dyes (known as indicators). A common such indicator is litmus (extracted from certain species of lichens), which is red in acidic solutions and blue in basic solutions. Although modern instruments can precisely measure various factors of acidity and basicity, indicators are still important.

Challenge:
Students enjoy using colored markers. Can a special set of toy markers be used to identify substances as either acidic or basic by investigating the reversible nature of indicators?

Time: 20 to 30 minutes

Procedure:
1. Provide students with some of the history and early-recognized properties of acids and bases (although the senses of taste and touch are no longer used, the color-change property is used to identify chemicals in the laboratory), students will:

2. Write or draw with the markers on paper, then with the color-change marker, sketch over some of the lines.

3. Swab both vinegar and ammonia on small pieces of indicator as well as over some marker lines.

4. First use vinegar and then ammonia on the same lines.

5. After data is collected, use the swabs to change the drawings.

6. Use data and indicator paper to identify the vinegar and ammonia as acid or base.

7. Use the colors associated with vinegar and ammonia to categorize color pens/white color-change pen as acidic or basic. (The inks in the colored pens likewise contain acid-base indicators that exhibit one color in acidic solution and another color in basic solution. The inks in the colored pens are acidic and the liquid in the white pens is basic. Once the dye is on the paper, its acid color can be changed similarly with the white pen or ammonia; the acid color can be regained by treating with vinegar.)

Further Challenges:

•Use acids (lemon juice) and bases (baking soda, Rolaids™, etc. dissolved in water) as variables.
•Shuffle marker caps and rematch.
•Use different indicators (cabbage juice soaked paper, phenolphthalein, pH soil testing paper, etc.. Cabbage juice contains a mixture of such dyes and so can exhibit a variety of colors:

pH	1	3	5	7	9	11	13
	red	rose	purple		blue	green	yellow

(A modern means of identifying acids is via the pH scale, in which acidic solutions have a pH value less than 7 and basic solutions have a pH value greater than 7; a pH of 7 is described as neutral. Some representative solutions and corresponding pH values: stomach acid, ca. 1.7; carbonated drink and vinegar, ca. 3; rain, ca. 6; blood, ca. 7.4; baking soda, ca. 8.4; ammonia, ca. 12; and lye, ca. 13.)
•Try to identify the indicators present in each color pen, using the observed color changes and a reference book (such as the *Handbook of Chemistry and Physics*).

Safety Note:

It may be best to eliminate the phenolphthalein activity when working with small children who might put things in their mouths.

Connections:

Language arts: Use knowledge of acids and bases to create a story of the inhabitants from Acidic planet A and Basic planet B. What happens when they receive coded messages or when they meet? How and why will they benefit from each other? Illustrate with color-change markers.

References:

Discover Science Level 6. (1991) Glenview, IL: Scott Foresman and Company. 190-199.
Sarquis, Mickey and Sarquis, Jerry. (1990). *Chemistry is Fun: A Guidebook of Chemistry Activities For All Grades.* Vol. I.
Handbook of Chemistry and Physics. Cleveland, OH: CRC Press.

The Authors

John Williams is a Miami (of Ohio) associate chemistry professor and Co-director "Teaching Science With Toys", a teacher inservice program.
Jo Parkey is a TOYS program mentor and teacher at Smith Middle School in Vandelia, OH.
Karen Schunk was a TOYS participant and teaches at Harrison Elementary, Harrison, OH.

16 Toy Ladder

By: Alfred De Vito

Focus:
Neglecting air resistance, all objects fall with the same constant acceleration regardless of the mass. A dropped sheet of paper slowly sails to the ground. By contrast, a dropped object, such as a book, strikes the ground so rapidly it is hard to establish that it falls with constant acceleration. In a vacuum, each object would drop like a brick.

Materials:
One or more Toy Ladder devices
Stop watches - one to a group of two to four individuals. *Other devices that can be substituted for the stop watches are metronomes, human pulse rates, or a simple cadence of one-thousand-one, one-thousand-two, etc.*
Protractors - one per group. *Several cardboard triangles, for example, 30, 60, 90 degree triangles, and 45, 45, 90 degree triangles could be constructed and substituted for the protractors.*
Graph paper

Resource:
Toy Ladder devices can be purchased from local toy stores or direct from the manufacturer NOVA PRODUCTS, Rd. 2, Box 2940, Bristol, VT.

Q Can the rider descend the ladder when the ladder is in the horizontal position?

Q How high must the ladder be elevated before the rider descends the ladder?

Q Why does it take longer for the rider to drop the full length of the ladder when it is in the full vertical position (90 degrees) as opposed to a 60 degree position?

Challenge:
Can you determine the angle for the toy rider to descend the ladder in the shortest period of time?

Time:
two to three class periods of 40 to 60 minutes

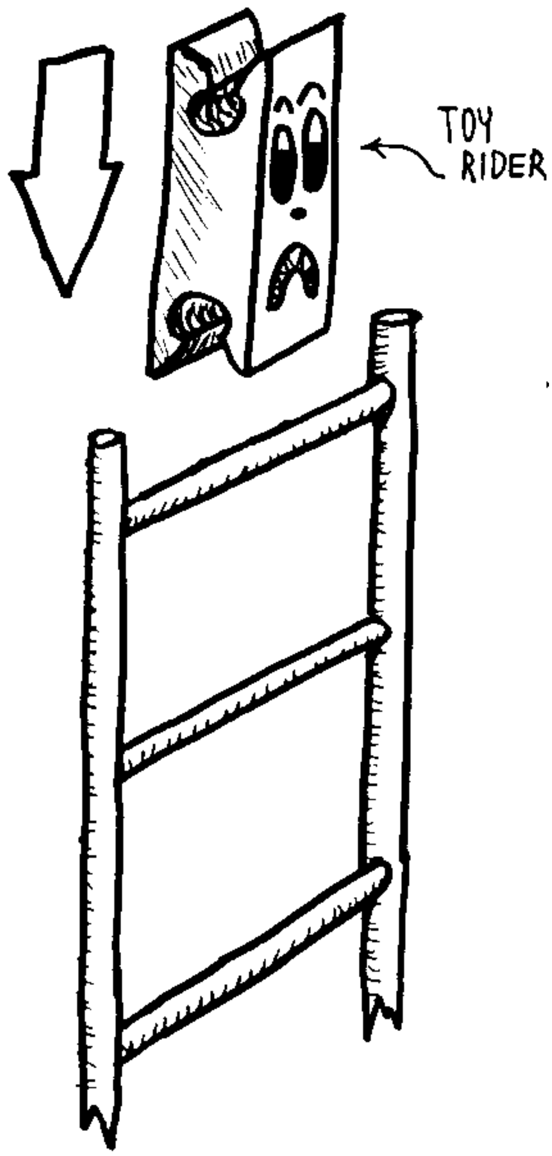
Procedures:
1. Place the toy rider on the ladder. Rest this device horizontally on a flat surface such as a table or desk top.

2. Elevate the ladder from its horizontal position. Using protractors or the cardboard triangles, have the students observe at what angle the rider begins to descend the ladder. Movement of the rider down the ladder can be observed at about 45 degrees from the horizontal. Usually the rider will descend only part of the way. The rider, because of the low angle and friction, has insufficient momentum to go all the way down and it comes to rest at some upper portion of the ladder. Have the students record the angle which first sets the rider in motion.

3. Increase the elevation of the ladder. Observe and record the angle which first allows the rider to descend the full length of the ladder. This angle should approximate 60 degrees. The children should also record the time of descent. These actions may need to be repeated several times to arrive at some verification and validation of both angle and time. Average out the data received from all groups to arrive at class agreement on the angle and time of descent.

4. Increase the elevation of the ladder so that it forms an angle of 90 degrees with the flat surface of the table. Have each

group observe the angle and the time of the rider's descent. Average out the data received from all groups to arrive at class agreement on the angle and the time of descent. In the 60 degree inclined position, the average descent time is about 3 seconds. In the 90 degree position, the average descent time is about 4 seconds. This usually poses a "How come?" question. Additional observations of the falling rider in both the 60 and 90 degree positions reveal that the rider dropping vertically (90 degrees) momentarily pauses as if to balance itself on each rung of the ladder. In the inclined position (60 degrees) the rider's descent results in a smoother transition from one rung of the ladder to the next thereby resulting in a speedier descent.



Further Challenges:

- Have the students plot the data on a graph. On the X axis of the graph list the various angle positions of the ladder. On the Y axis list the units of time.
- As an added involvement substitute an inclined plane and a rolling ball for the toy ladder device. By manipulating the elevation of the inclined plane, the time of descent of the rolling ball can be slowed or speeded up. Ask the children to contrast the toy ladder results with the inclined plane results and offer explanations for differences in time versus angles.
- Another extension would be to change the mass of the falling rider (or ball when using the inclined plane) by adding or removing some of the mass of the object and inferring what the effects of this change might be on the rate of descent. Have the children support or refute prior inferences based on their collected data.

Assessment:

Upon completion of the toy ladder activity, involvement with the inclined plane activity and evidence of transfer of related understandings from one activity to a similar activity would provide a form of assessment.

The Author
Alfred De Vito is Professor Emeritus of Science Education at Purdue University, West Lafayette, IN.

17 Blaster Balls

By: Penny Wagher

Materials:
at least two sets of Blaster Balls
a variety of other balls with different surfaces
paper
pencil

Safety Note:
The manufacturer cautions against use of Blaster Balls by children eight years and under, and use closer than one foot

Q What do you think is special about these balls?

Focus:
When a chemical reaction occurs either heat is given off, exothermic, or heat is absorbed, endothermic. During the chemical reaction many changes occur. Some can be seen, observations, and others just inferred. When blaster balls are used the heat can be felt, but no change seems to occur to the balls unless they are examined closely.

Challenge:
Student will predict, experiment, and try to prove their hypothesis of -- What happens when blaster balls collide and why does it happen?

Time: 40 - 60 minutes

Procedure:
1. Pass ONE ball to each student to examine, making sure that no one has two balls at one time.

2. Encourage the students to use all their senses, except taste, to examine the ball. Provide magnifying glasses.

3. Retrieve the blaster balls and perform a demonstration. Throw a ball into the air and catch it with the hand holding the second ball, producing a loud bang. Turn off the lights for one throw.

4. Guide the line of questioning without giving answers. Make sure the students understand the difference between an observation and an inference.

5. Example questions:
•What are your observations?
•Do the balls have to hit each other in order to blast? How can we test this?
•How can the blast be produced?
•Why does the blast occur when the two balls collide?
•What would happen if I held each ball in one hand and lightly tapped them?

•Will a blaster ball "blast" when it hits a different kind of ball?
•Do these results suggest that a change in theory might be needed?
•What if I scrape the two blaster balls together with a fast motion?
•Perhaps blaster balls and matches have similar characteristics.
•When the surface of a ball is rubbed with another blaster ball what happens to the temperature of that surface?
•How does rubbing a smooth surface rather than a rough surface affect the temperature change?
•The floor and the table are smooth. What happens if I throw the blaster ball on a rough surface at an angle so that the ball scrapes the surface?

Assessment:

After the discussion, before the students get a chance to handle two balls at once, have each student write two paragraphs. The first should relate their observations and inferences from the demonstration. The second paragraph should be their conclusions and the data that provide them.
Observe as the students work in pairs to find different ways to produce a blast using their two balls.

Q Could you put a coating on a ball to produce a blaster ball?

Further Challenges:

Discuss the three pieces of evidence that prove that the energy released is exothermic. (light, heat, and sound are all produced).

Connections:

Mathematics: Construct a chart or a graph displaying all the information learned concerning blaster balls.

Reference:

Park, John C. (1991). "Inquiry is a Blast", *Science Scope*. April, 24-28.
Romey, William D. *Inquiry Techniques for Teaching Science.* Englewood Cliffs, NJ: Prentice Hall. 16-18.

The Author

Penny Wagher is a teacher at Lincoln Elementary School in Monmouth, IL.

18 Hands on the Floating Clay

By: David R. Stronck

Focus:

Children know that cork and styrofoam float in water while nails and clay sink in water. Boats and ships can be made of iron and even clay if they have the shape needed to float. The children will discover the needed shape by molding clay and will be able to explain why one shape is better than another.

Materials:

Clay - enough for each child to have equal amounts (about 1" cube) of soft clay.
Paper clips: several boxes with at least 100 in each.
Shallow pans or pie plates with some water in each.
Water

Challenge:

How can a piece of clay float? If I put a ball of clay into a cup of water, I see that it sinks to the bottom. You can change the shape of the clay. What shape will allow it to float?

Procedure:

Classroom organization: Several children may be placed at each pie pan that is half filled with water. Each child should receive a small cube of clay. A box of small paper clips should be immediately available.

Introduction: Demonstrate that a ball of clay sinks in water. Demonstrate that a metal paper clip also sinks. Ask the children to explain how boats and ships float in the sea. If the children remain puzzled, ask them to describe the shape of a row boat. Lead the students to recognize that the average density of the boat is less than water because of the contained air within the boat.

Q If metal sinks, how can a metal ship float?

Q Why does the shape of a metal row boat allow it to float?

1. Invite the children to build a boat made from clay. Encourage them to have a contest to find out who can make the best boat. Define the "best boat" as the one that can carry the largest load of paper clips before it sinks. Let the students discover that the larger the cup, the better will be its ability to carry paper clips. to enlarge the size of the boat, the children will need to make the clay walls relatively thin.

Q What characteristics should be a part of all "best boats"?

2. Tell children to count the maximum number of paper clips they are able to put in their boat before it sinks. Make a class bar graph or histogram of the number of paper clips.

3. Study the boats that could hold the most paper clips.

Q What do all "best boats" have in common?

Identify the characteristics that these boats have in common.

4. Ask students to predict what should be done to their boats to improve the number of paper clips they can hold. Allow all children to modify their boats using the information gained through boat observations.

Assessment

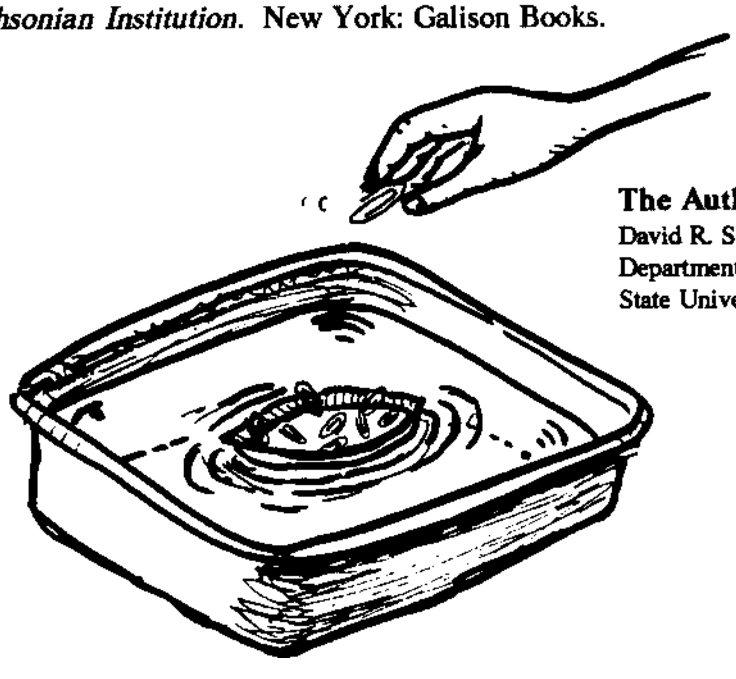
The goal is to develop the concept of bouyancy from the experience of observing the behavior of clay boats. Can the students explain why clay does not float, why clay boats do float, and what are the characteristics of a clay boat that can carry a large load of paper clips? The student(s) who can provide these explanations deserves the highest grade for the performance, not necessarily the student who designed the boat that could hold the largest number of paper clips.

Further Challenges

•Boats will sink if they have a leak. Can the students construct a boat that will not sink? What types of materials can be used?
•Submarines can rise and dive in the sea. This can be done by compressing air into small tanks and releasing this air into other tanks while expelling water from these tanks. Invite students to design and build a submarine

References:

Clay Boats, Reader and activity cards, Delta Education.
Levenson, Elaine. (1985). *Teaching Children About Science.* New York: Prentice Hall.
Solimini, Cheryl (ed.). (1988). *More Science Activities: The Smithsonian Institution.* New York: Galison Books.



The Author
David R. Stronck is a professor in the Department of Education at California State University in Hayward, CA.

19 Legomania

By: Karen Ray and Sandy Burke

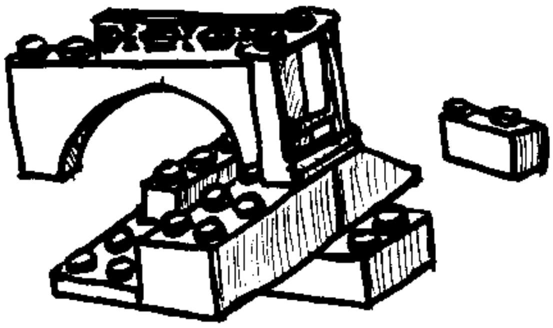
Focus:

Activities 1, 2, and 3: Children in grades 3 to 6 will use Lego™ building blocks in 3 unique ways that will encourage them to listen carefully, follow directions, make predictions, observe, and/or problem solve.

Materials:
Activity 1 - A class set of Ziploc™ bags, each filled with 6-10 Legos™ and instructions for making mystery objects. Answers should be on the back of the instructions.
Activity 2 - Tub of Legos™

Challenge:

Activity 1 - After reading a set of directions and viewing the Lego™ pieces needed to construct a "mystery object," can you predict what the object is? Then can you follow the directions. to build the object correctly?
Activity 2 - How good are you at giving clear directions? Can you listen carefully and follow oral directions well? By listening carefully and following the directions your partner gives you, can you construct an object out of Legos™ that is identical to your partner's object without seeing what he/she is doing?



Time: One class period should be sufficient for each of the three activities.

LEGO

Activity 1

Procedure:
Individual children or pairs will be given a Ziploc™ bag filled with 6-10 Legos™. Inside the bag there will be a set of directions for making a mystery object. The children will read the directions and look at the Legos™ in the bag. They will try to predict what their mystery object is. After predicting, they will follow the directions to see if their
prediction was right. Afterwards, they will tear the mystery object apart and lock the Legos™ and instructions in the Ziploc™ bag, making the activity ready for the next student.
Assessment:
Did students predict correctly? Does the object look like they had initially predicted? They may look on the back of their directions to see if they were correct.
Further Challenges:
•Did you identify any problems? What were they, and how did you solve them?
•Was it easy to predict the mystery object? Why or why not?

Q Was this activity harder or easier than the usual way you may have played with Legos™? Why do you think so?

•What might you do to make this activity more challenging?
Connections:
Math: Construct a graph indicating the number of students who were able to predict correctly and build the mystery objects.
Language Arts: Write your own directions for making an object and put them with the proper Legos™ into Ziploc™ bags. Have other children predict and build these mystery objects.

Q Which mystery object was completed correctly by the most children?

Activity 2

Procedure:
Pairs of children will work together on this activity. The leader of the pair will pick out two identical sets of 8-10 Legos™ — one set for each child. The children will then sit down back to back with Legos™ on their laps. The leader will give directions for building with the Legos™. The other student will listen to the directions and try to make an object that is identical to the leader's. When all Legos™ have been used, the two students will compare objects. Are they alike? Did the leader give good directions? Was the listener able to under stand the directions well enough to make an identical object? Students can then change places and try again. Use the same procedure. Compare objects. Are the objects alike? Was it easier this time? Students should discuss problems they may have had and make suggestions that might help if they work together again.Students should take Legos™ apart and put them back in the tub.

Further Challenges:

•What might you do to make this activity easier?
•What might make this more challenging?
•Provide two children with a set of Legos™ mixed together in a Ziploc™ bag with pictures of two objects that can be made from the pieces. Provide the two student teams with 10 minutes to construct the object without talking to one another, so other forms of communication may be necessary in order to get the correct pieces for each object.When time is up, students can check to see if they have constructed the objects correctly.

Connections:

Math: Keep track of the time it took them to complete one object. Repeat the same activity several more times. Graph how long it took to finish with each attempt. Did they improve their speed? Why?
Graph how long it took to finish each of the three objects. Which took the longest? Why do you think this was so?

Q Which object was constructed most quickly?

The Authors
Karen Ray is a third grade teacher and Sandy Burke teaches fifth grade at Norris City-Omaha Elementary School in Norris City, IL.

20 Light and Bright Communications

By: Sharon Knight and Karen Lewis

Materials:
Per student-
One recycled and bleached styrofoam cup
Ten "Lite Brite™" pegs

Focus:

What senses do you use in playing a game? Maybe you use more than you think. Some of our senses are involved in every game we play. Using their sense of hearing, touching, speaking, and vision in a fun way to communicate to each other children will develop communication skills.

Challenge:

Students will be involved in a communicating process using "Lite Brite™" pegs and a recycled styrofoam cup to make a design by following the directions of a partner.

Time: ten minutes

Procedure:

1. Organize students into pairs. Both partners group all of their pegs by color.

2. Partner #1 selects ten pegs. Partner #2 must match color and amount of #1's selection.

3. a. Partners are to sit back to back. Giving directions for only one peg at a time, partner #1 makes a design, shape or picture by poking the ten pegs into the outside of the cup. Each direction is given only one time.

b. Partner #2 tries to match the design, shape or picture with his pegs and cup by listening to the instructions given by partner #1.

EXAMPLE: Partner #1- "Place five red pegs in a straight line from top to bottom on the outside of a cup. Place five blue pegs in a line crossing the middle of the red line."

Partner #2 may not ask questions but may respond yes or no.

c. When finished compare to see if the cups match. Try again on another section of the cups.

d. Repeat the procedure when cups do not match. with partner #2 providing instructions this time.

Q Are your pegs placed exactly on your cup as your partner instructed?

Q Do your colors also match?

Assessment:

Finished product should look like the person's cup who gave

the directions. If the product is not the same ask students to determine whether the directions given were adequate or if the listening skills used by the student following directions caused the error.

Wrap-up:

•What problems did you have giving directions?
•What problems did you have when following directions?

Further Challenges:

•Provide each student with more pegs.
•Provide students with a greater variety of colors.

Connections:

Mathematics: Make up story problems using pegs.
•Use pegs for counters when learning math facts.
•Use pegs for matching, colors, and grouping.
•Use pegs for probability by guessing how many of each color will be picked from a three ounce cup.
Language arts: Ask students to orally describe to the class what they did during the Poking Pegs game

Reference:

Markle, Sandra. (1988). *Hands-On Science.* Cleveland, OH: Instructorr Books, Inc.
Richardson, Kathy. (1984). *Developing Number Concepts Using Unifex Cubes.* New York: Addison Wesley.

The Authors

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21 Water Rockets

By: Nina Salamon

Materials:
water rocket and pump
plastic buckets
water
Altitrak™

Resources:
Water Rockets
Parks Plastics
Linden , N. J.
or
in season (spring and summer) at toy stores usually at a discount.
Altitrack™
Estes Rockets
1295 H Street
Penrose, CO 81240

Safety Note:
Remind students to use caution when launching. They must be aware of other students who may be in their path and for rockets being launched by others. You may want to set minimum distances between students. Rockets should never be lanched sideways, only launch vertically. You may want to establish "rocket spotters".

Q What causes the water rockets to travel?

Focus:
Newton's Third Law states that for every action there is an equal and opposite reaction. It is really a law that describes the nature of forces. All forces come in pairs called action forces and reaction forces. Newton stated that the action force and the reaction force always act on different and complementary objects - when A exerts a force on B, then B always exerts an equal but oppositely directed force on A. This activity provides the opportunity to investigate the relationship between exerted force and the resulting reaction. Students identify and manipulate variables, predict outcomes and test predictions. They gather data, summarize it on a graph and write a research report.

Challenge:
Test two variables you have chosen to work with in trying to make your rocket go as high as possible. Gather enough data to "prove" or "disprove" your theory.

Time: The entire project, including report, can take up to 3 months. It can take as few as 10 class sessions for testing and reporting.

Procedure:
Classroom management: Students may work on their own or you may establish partners. Some sessions will necessitate taking students out of doors, this makes water rockets a fair weather activity. This is not meant as an introduction to science processes. Students should have a working knowledge of observation skills, variables, establishing a control, keeping records, inferring, designing a test, safety, and conducting investigations.

1. Take class outside and allow students time to investigate the rockets. Give each student (or 2 partners) a water rocket and provide buckets of water for filling. Provide time to "play around" with the rockets and learn how to make them work -no direct instruction.

2. Assign students to determine what causes any rocket to move forward. Allow library time to investigate Newton's

third law. Have student teams prepare demonstrations to explain Newton's third law to the rest of the class.

3. Relate the information gained in the first two class sessions to one another. Discuss the variables that affect the height at which the water rocket will travel. Permitted variables might include -- amount of water (best), amount of air, temperature of water, liquid used (limited to soda water, salt water and plain water), direction of fins (and presence and absence of them), and boosting vs. not boosting. Ask students (either indiviually or with a partner) to infer how they might manipulate their rocket to go higher. Discuss control of variables, manipulation of only one variable at a time (you may want to limit each student to a total of two variables), establishing a control, keeping accurate records of their investigations, and other science skills.

Q How can you test your inference?

Q How many times should you conduct each test?

Q What variables must you control, and how will you control them?

4. Have students make a testing plan and construct data tables for recording their tests.

5. Demonstrate how to use an Altitrak™ and practice the method of measuring height of the rocket.

Q What is the average height attained for each variable test?

6. Provide additional out-of-doors sessions (may take 2-6 depending upon group and team arrangement). Have students test their inferences and manipulate variables. Ask them to keep records in their science journals and on data charts.

Q How could you graph water rocket data to show a comparison between variables tested?

7. Introduce the research paper and explain the use of primary research (water rocket data) and secondary research (information gathered in the library on Newton's third law).

Q What could you do to find out more about Newton's third law?

Assessment:

Take into account all the work done: planning the project, following directions, writing, graphing, averaging, showing understanding of the results, showing understanding of controls and sources of error, and library research.

Connections:

Language arts: In preparation for research, instruct students in proper note taking strategies, outlining, bibliographic cards and bibliography preparation.

Author
Nina Salamon is a sixth grade teacher in New Haven, CT and is a PIMMS Fellow.

References:

Rothman, Milton A. (1963). *The Laws of Physics.* New York: Basic Books, Inc.

22 What Makes Ratstuff Flip?

By: Susan M. Johnson and Richard Dettmer

Materials:

Each group of four students will need:
A wind-up animal toy, such as Ratstuff™, that does back flips
sheet of newsprint or other blank paper for drawing
marker, crayon, or pencil for drawing

Focus:

Wind-up toys are designed so that the energy put into them by winding can be stored, transferred, and then applied in just the right amount. In this activity students use observation, inference, and questioning to analyze how a toy works. They observe the somersaulting of "Ratstuff™," a pink, plastic, wind-up animal that was part of NASA's Toys in Space program. Then they propose a mechanism that would produce the action.

Students observe that after it has been wound, Ratstuff™ tilts forward very gradually, then suddenly flips over backwards and lands on its feet. Inside, as the toy unwinds, a lever makes the body tilt forward and stretches a spring. When the lever slips past a cog on a turning wheel, the lever suddenly is released allowing the spring to unwind, and the force is great enough to make the toy flip over backwards. The toy's symmetry and wide base help it to land on its feet. Ratstuff™ contains a set of simple machines, which include gears, wheel and axle, and a lever.

Challenge:

Draw a picture of what could be inside Ratstuff™.

Time: One to two class periods

Procedure:

Classroom management: Organize students in groups of four, seating them at a flat, smooth, hard surface such as a desk top or uncarpeted floor.

1. Give each group of students one Ratstuff™ or similar flipping toy, and direct them to find out what they can about its behavior by making observations. When students finish their play and observations, they record their findings.

2. Invite the entire class to discuss and compare observations.

3. Ask students what questions they have about Ratstuff™. Students usually wonder what is inside.

4. Invite students to brainstorm with each other about what might be inside. Have each student form an inference concerning what makes Ratstuff™ work and ask them to draw their inference. Students should have continued access to the toy to analyze its action.

5. Ask each group member to describe their drawing to their group and explain how the mechanism might work.

6. Allow students to prove or disprove their theories by observing the workings in a Ratstuff™.

Assessment:

Written observations, drawings, and discussion will indicate if students noted key points such as the pattern of changes in Ratstuff's body position which results from the stretching and release of a spring, and the whirring sound of the gears which regulate the release of energy from the mainspring. Drawings may differ from the actual mechanism, but should show good thinking about storing, transferring, and using energy through a combination of simple machines.

Further Challenges:

•Predict how Ratstuff™ would perform in space. Then watch NASA's " Toys in Space" tapes for actual footage.
•Explore other wind-up animals, such as chicks that hop and penguins that strut. Infer how the inner workings compare to Ratstuff's.
•Explore gears on bicycles to see how the rear wheel gear makes the wheel turn faster than the pedals. Observe the gears as you shift from high to low. Find out when the large and small gears on the back wheel are most useful.

Connections:

Math: Make quantitative observations of Ratstuff™, such as the number of jumps which result from a given number of winds.
Literature: Read the tales of other adventurous rodents, for example *Stuart Little, Tucker's Countryside, Frederick, The Rats of NIMH, Harry Kitten andTucker Mouse, Christmas Mouse,* and *The Mouse and the Motorcycle.* Write a story about a space rat or a rat that does back flips.

References:

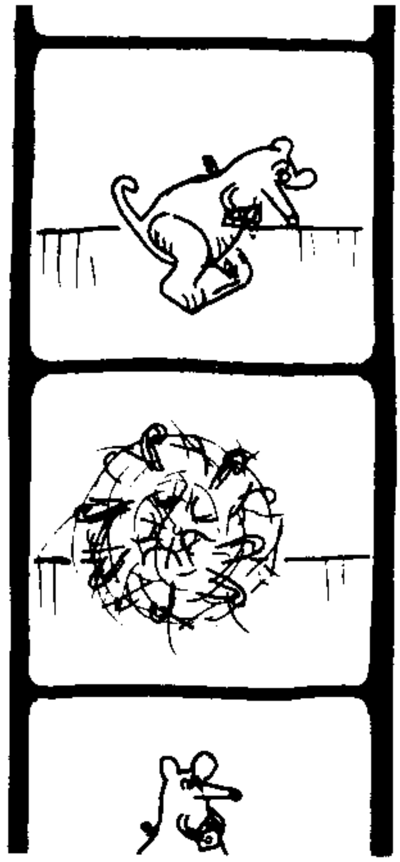
MacCaulay, D. (1988). *The Way Things Work.* Boston: Houghton Mifflin Co.
Wilkin, F. (1986). *Machines.* Chicago: Chicago Press.

Q What sort of a thing inside could make the body slowly lean forward and then suddenly flip backwards?

Q When you add energy, as you turn the winder, what sort of thing could store the energy?

Q After you have stored the energy, what sort of thing could slow down the release of the energy?

Q What do you think could make the whirring sound?



The Authors
Susan M. Johnson is a Professor of Biology/Science Education at Ball State University in Muncie, IN.
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23 Finish The Picture

By: Debra L. Barker

Focus:

This activity works with prediction and inferring, both are necessary techniques in problem solving and should be encouraged at an early age. Challenge: Can you predict what the finished picture will looked like?

Materials:
overhead projector
multiple copies of an action scene or a sequence of events picture from achildren's coloring book or puzzle and one transparency of each
pencil and crayons or colored pencils

Advance Preparation: Prepare pictures from a child's coloring book or puzzle eliminating pieces and then reproduce the picture allowing the child to predict and draw in the missing pieces.

Time:
One class period or can be extended to several class periods.

Procedure:

Classroom management: This activity can be done in any organizational manner the teacher chooses. Try beginning with a class activity to illustrate the procedure then move into small groups or individual work areas. Choose a picture with action or a sequence of events.

1. Begin with a simple picture that will be easy to predict. Ask students what is missing or what will happen next. Move to a more difficult picture and repeat the same procedure. This may be done 2 or 3 times before moving into smaller groups.

2. Provide students with a new picture to complete on their own. Have each student draw what they think will happen next in the scene.

3. Establish cooperative groups and have the students compare their pictures to what others have drawn. Ask them to explain why they selected various parts of their scenes. Have each group select the most logical picture created by one of their group members to show and explain to the class.

4. Discuss predicting and forming inferences. Ask students to note which group choices are similar to one another. Lead them to understand why several students may make similar drawings.

Q What is needed to make good predictions?

Further Challenges:

•Introduce a variety of more complex predicting or inference activities. Provide each student with a sealed container such as a film canister. Place an object that will make a sound when

the canister is shaken in each (bean, coin, small paper clip, marble, washer, pencil top eraser, chalk, etc.). Ask students to investigate their container without removing the lid and try to infer what is in their container.

Q What clues did you have about the contents of your container?

Connections:

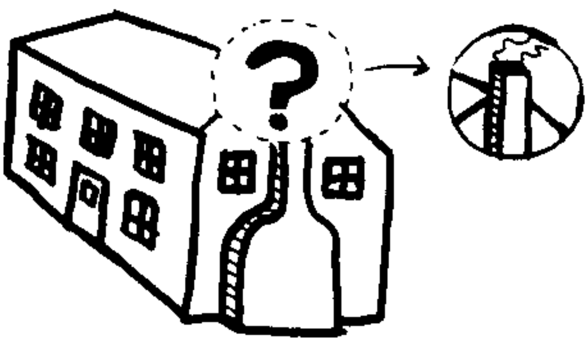
Language Arts: Finish a story or poem based on prior knowledge, or give supporting information based on prediction.
•Draw several scenes showing imaginary tracks in snow, each on a seperate piece of poster board or on overhead transparency film. The first science should show two sets of tracks heading toward one another. The second shows the tracks overlapping. The third shows just a single set of tracks. Based on the tracks, ask students to explain what happened in this snowy field.
Technology: Discuss types of inventions that might exist in the future.

Assessment:

•Discussion about why they chose to finish their picture as they did would evaluate their understanding of prediction and inference.
•Place an object in a sock for each student. Allow them to investigate the sock without looking inside. Ask them to infer the contents of the sock and explain how they determined their inference.

Reference:

Ostlund, Karen L. (1992). *Science Process Skills: Assessing Hands-on Student Performance.* Menlo Park, CA: Addison-Wesley Co.
Makle, Sandra. (1988). *Hands-On Science.* Cleveland, OH: Instructor Books.



The Author
Debra L. Barker teaches at East Side Elementary School in McLeansboro, IL.

24 Pick Up Sticks

By: Marie McCrillis, Kathy Miller, Judy Ochs, and Joyce Wilson

Materials :
Each group will need:
Pick Up Sticks - wood & plastic
meter stick
ruler
various surfaces (flat, smooth, rough, etc.)
protractor
paper

Safety Note:
The tips of Pick Up Sticks are sharp. Remind students to not poke others or inappropriately play with the sticks.

Q How do variables such as height and angle of drop, surface, and grip effect the game of Pick Up Sticks?

Q What is the largest angle created by your group members? In what geometric shape was it found?

Q What is the length of each side of the shape?

Focus:

Pick up sticks can be used for more than just play. Part one of this activity allows students to explore the variables involved in the Pick Up Sticks game. Part two uses Pick Up Sticks as a tool for making shapes to be analyzed by students.

Challenge:

Students will use Pick Up Sticks to identify geometric shapes, angles and different patterns.

Time: two or three class periods

Procedure:

Classroom management: Students may work in pairs or cooperative groups.

1. Explain the original Pick Up Sticks game. Have students explore with Pick Up Sticks. Identify variables to be investigated. Discuss how to control variables, number of tests necessary to gather enough information and how to accurately record data for their tests.
•Compare wood with plastic sticks by dropping sticks from different heights.
•Compare wood with plastic sticks by dropping sticks on different surfaces.
•Compare wood with plastic sticks by dropping sticks vertically versus horizontally.
•Compare wood with plastic sticks by changing hand positions on sticks each time they are dropped.

2. Review shapes by discussing number of sides, angles, and measurement with students. Have students take turns creating geometric shapes with their sticks. If they are having difficulty, have them locate geometric shapes in the classroom, place sticks along the edges of the shape (could start with a piece of paper), and duplicate the shape for group observation. Other students in the group determine and name the shape. Using a protractor, measure the angles created by the sticks.

Further Challenges:

•Pose "what if" questions, (example: What if the sticks were shorter? What if sticks were made of foam rubber?).
•Brainstorm other uses of sticks. Identify a problem that could be solved by using Pick Up Sticks.

Connections:

Language Arts: Write accurate instructions for playing a champion game of Pick Up Sticks. Be sure to use the information gained in this investigation.

References:

Levenson, Elaine. (1985). *Teaching Children About Science: Ideas and Activities Every Teacher and Parent Can Use.* New York: Prentice Hall.
Wilt, Joy and Hurn, Gwen. (1978). *Game Things.* Waco, TX: Creative Resources.

The Authors

Marie McCrillis is a first grade teacher at Rose Hill School.
Kathy Miller is a second grade teacher, Judy Ochs is a fourth grade teacher, and Joyce Wilson is a teacher of the gifted and remedial reading at Ste. Marie Elementary School. They all teach in Jasper County, IL.

25 Wind Me Up And Watch Me Go!

By: Pat Shier and Libby Laughlin

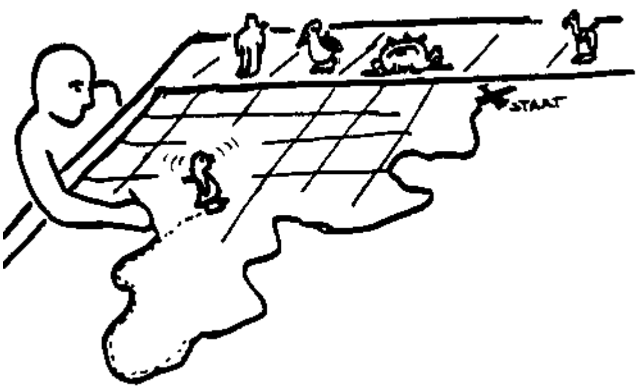
Materials:
overhead projector
wind-up toy
Each group of 2-4 students will need a kit containing:
a different small wind-up toy
an 18" x 24" piece of newsprint or chart paper
crayons
string
scissors

Focus:
Machines do all kinds of work. Some lift heavy objects, some help us build houses, some prepare our food, some carry us into space. The same principles of work, energy and energy transfer present in these complex machines are also present in many toys. Relationships between motion and energy, distance and energy, and time and energy can be explored using simple wind-up toys. Energy is the ability to do work.
Work = Force X Distance moved in the direction, or: W = Fd
The activity that occurs when work takes place is the result of the energy that is transferred from one body to another in the process.

Challenge:
Students will estimate how far the wind-up toy will travel after being wound 5 complete "turns".

Time: Two or three 20 minute class periods

Procedure:
1. Begin by asking students what they think will happen if the toy is wound up. After discussing their ideas, wind up the toy a few turns and place it on the overhead for all students to observe. This is a good time to model how to wind up the toy and to define a "turn". Note: Most wind-up toys can be wound up to 7-10 turns without breaking the spring drive.



2. Each cooperative group is given 1 wind-up toy and allowed time to take turns winding up the toy and observing its motion.

3. Have each group discuss their observations and record their findings in their science journals (or have the group recorder report to the class on the group's findings).

Q How can you be sure that each student starts their wind-up toy at the same location?

4. Begin the next session by giving each group a complete set of equipment as listed in the "Materials" section. An "X" should be drawn in the center of the paper, the wind-up toy will be placed here (with leading edge -toes- touching one of the cross bars of the "X") to start each child's turn. Discuss measuring the distance a toy travels by drawing its path and

overlaying it with a piece of string which can then be measured.

5. Students are then asked to estimate how far their toy will travel after it is wound up 5 turns and released. Students are to cut a piece of string the length of their estimate. Once estimates are established, students may test their toys.

6. After all strings are cut, each student chooses a crayon to use for tracing the path, the toy is wound-up 5 times, positioned on the X and released. As it moves, its path is drawn. This is repeated for each student.

7. After all students have taken a turn, they should place their cut string along the line they drew for the path. They can then compare actual (crayon line) to estimate (string). If you have selected several types of wind-up toys for the groups, they can now trade kits and repeat the process.

8. Discuss which wind-up toy has the most efficient use of energy to do work.

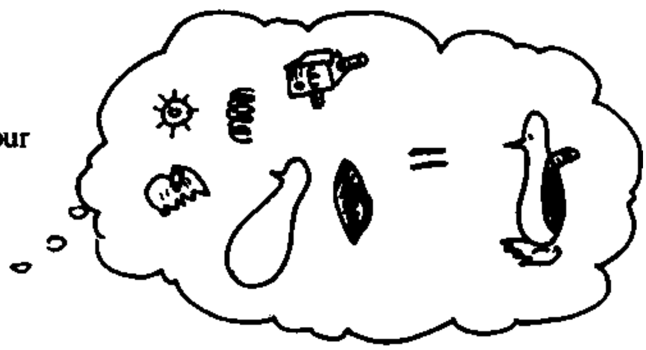
Assessment:
The following questions might be asked to determine understanding and ability to make logical predictions.
•Why do you think the toy traveled more, less or equal to your estimate?
•Did the toy travel the same distance each time?
•What do you think made a difference as to how far the toy traveled?

Further Challenges:
•What would happen if you wound the toy more? Less?
•What do you think would happen if you started by pointing the toy in a different direction?

Connections:
Mathematics: Create graphs showing estimate and actual distances for each group.
Technology: Construct a timing device to measure the amount of time the toy moves.
Social Studies: Allow the toy to "travel" across a large U.S. map, name the states crossed during the trip.
Language Arts: "If you were a wind-up toy where would you want to go?"
Art : Make a picture from the design the wind-up toy made after its five trips across the paper.

Q How can you measure the distance traveled when some of the toys do not travel in a straight line?

Q Why would one wind-up toy be more efficient than others?



Q What could you do to make the toy change the direction it traveled?

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26 Space Balls

By: Stephen Marble

Materials:
metric rulers
collection of assorted sized balls, from marbles to beach balls.

Focus:

The earth's moon is perhaps the most easily identified celestial object in the sky, but one about which most of us actually know very little. Many Earth/Moon concepts are extremely difficult for K-12 students, including understanding why the Moon has phases, why we never see the "backside" of the Moon, why we can sometimes see the Moon during the daylight hours, and how lunar and solar eclipses occur. The relationships between both the relative sizes of the Earth and Moon as well as the distance between the Earth and Moon are two important ideas that provide a concrete foundation for more complex conceptual understandings of the Earth/Moon planetary system.

Challenge:

Students will explore their understandings of the scale size and distance relationships between the Earth and the Moon using an assortment of different dimensioned balls.

Time: One class period (approximately 45-55 minutes).

Procedure:

1. Organize students into teams of two or three. There should be about twice as many balls of assorted sizes as there are groups of students. Place balls where students can easily pick and choose.

2. Ask students if they have ever heard of the word "scale" used when talking about distances or relationships. Ask what they think it means. You might have a road or wall map available to permit students to explain scales on maps.

3. Challenge each team of students to use the idea of scale to choose two balls from the collection that represent the scaled relationship between the size of the earth and the size of the moon. Exhibit one ball and say "If this is the ball you have chosen to represent the earth, how large a ball would you choose to represent the moon at the same scale?" Have them discuss ball selection and agree, as a team, as to choice and rationale.

Q Which two balls do you think represent the proper scale relationship between the Earth and the Moon?

4. After each team has chosen two balls, ask each team to stand

with their choice and justify their decisions.

5. Once each team has had an opportunity to describe their selection, ask the class if anyone knows how to determine a ratio to describe the relationship between the sizes of their earth and moon. Students might propose several unique ways, including using volume or circumference. Explain that one way would be to compare the diameters of the two balls.

where D = diameter of "Earth" ball	
and d = diameter of "moon" ball	
ratio of diameters	= D : d
	= D/d : d/d
	= D/d : 1

Each team should use a ruler and measure the diameters of their two balls and complete the equation, arriving at some ratio like 5:1 or 4:1 or 3:1. Have each team report their ratio.

6. Ask students if anyone knows the approximate diameters of the Earth and Moon. (Don't expect them to). Provide students with the following actual values and have them complete the ratio exercise once more to find the approximate accurate ratio.

(Earth) D = 12,800 kilometers	
(Moon) d = 3,200 kilometers	
and the ratio	D : d = 4 : 1.

7. Once students calculate the approximate ratio, have them search for two balls that have a 4:1 ratio. State that the "earth" and "moon" they now hold represent the Earth/Moon model in correct size scale relationship.

8. Now challenge each team of students to hold each ball about as about as far apart, in scale, as they think the earth and moon are from one another. Remind students that they will be required to justify their guesses. Ask teams to demonstrate.

Q Once you determine two balls with the proper scale dimensions, how far apart must you stand to represent the approximate distance between the two celestial bodies?

9. Ask students how we could use what we know about scale to estimate an approximate distance relationship for the model balls. If students have suggestions, explore them. Prompt students to think of mathematical ways to accomplish this idea.

10. If students cannot solve the problem, you might assist them by suggesting the following information.

•We know the diameter of the Earth is about 12,800 km.

•We know the diameter of our earth ball is about Y cm.
(choose one from a pair of students).

•We also know the distance to the Moon from the Earth is about 384,000 kilometers.
•We could build an equation that relates these numbers as follows:

$$\frac{\text{distance from Earth to Moon}}{\text{diameter of Earth}} = \frac{\text{X (scale distance)}}{\text{diameter of earth model}}$$

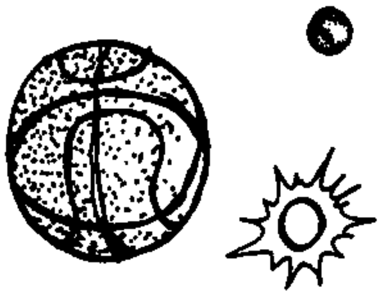
$$\frac{384{,}000 \text{ km}}{12{,}800 \text{ km}} = \frac{\text{X (scale distance)}}{\text{Y cm (from student example)}}$$

$$30 \text{ (Y cm)} = \text{Scale Distance}$$

If the student model selected had an earth model diameter of 10 cm., then the scale distance would be 30 (10 cm.) = 300 cm, or 3 meters!

Q Where would the Moon be placed if Earth were the size of a basketball?

11. Have each pair calculate the scale distance for their earth/ moon model and then hold their earth and moon balls approximately the correct distance (in scale) apart. Remind the students that the distance they stand is a scale distance and is determined by the size of ball they choose for their earth model. The larger the ball, the greater the distance.



12. **Wrap up:** Remind students that scale helps us to imagine relationships that we cannot actually see or even imagine. The two scale notions that the students have calculated should be easy to remember: the size relationship between Earth and the Moon is about 4 : 1, while the distance relationship between Earth and the Moon is about 30 Earth diameters.

Assessment:

•Ask students to complete a similar task using the Sun and Jupiter, or Saturn and its moon, Titan.

Further Challenges:

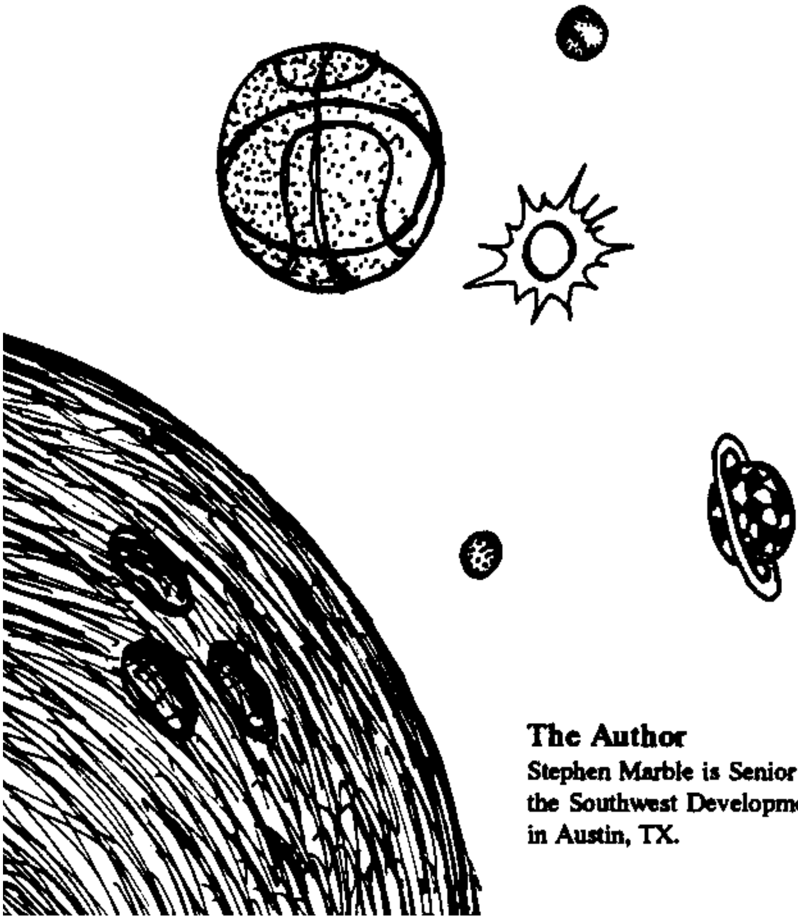
•Given the scale used for this activity, what would be the relative size and distance of the sun from Earth?
•Use the proportional model to investigate the rotation and revolution of the Moon/Earth system. Use a light source to represent the Sun.

Connections:

Mathematics: Investigate other situations in which it is important to use ratios.
Have students graph the distances of each planet in our solar system to the Earth.
Language arts: Create a story or poem given the plot of objects not being in the proper proportion.

Reference:

Astronomy. (1992). Austin, TX: Southwest Educational Development Laboratory.



The Author
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27 Hit The Breaks

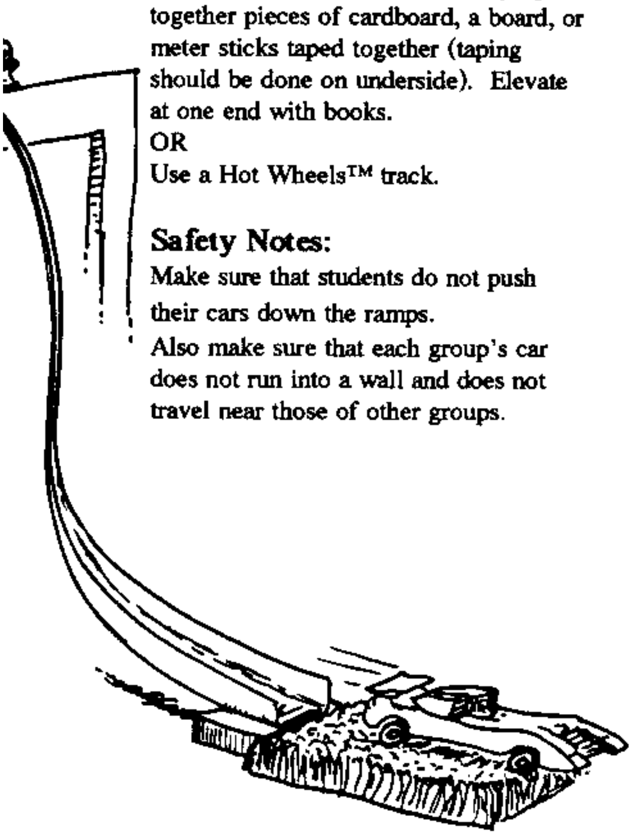
By: William J. Boone

Materials:
5 different toy cars - name each car
ski ramp-type ramp for cars
material over which cars will travel such as old posters, old carpeting of various densities, rubber car mats, sandpaper, etc
rulers
masking tape

Sources:
Most carpeting stores will gladly supply small remnants for use in this activity.

Advance Preparation:
A ski jump-type ramp can be constructed from large books, taping together pieces of cardboard, a board, or meter sticks taped together (taping should be done on underside). Elevate at one end with books.
OR
Use a Hot Wheels™ track.

Safety Notes:
Make sure that students do not push their cars down the ramps.
Also make sure that each group's car does not run into a wall and does not travel near those of other groups.



Focus:
This activity will help students learn the differing amounts of friction created by a variety of inexpensive materials. At the conclusion of the activity students will have observed the effects of friction on toy cars, measured the effects of friction, classified materials by the amount of friction they create, and predict the amount of friction created by each material.
When two objects rub against one another there is always friction. This is caused by the irregularities on the surfaces of the two objects. Two relatively smooth objects rubbing on one another cause little friction while, if the objects have rough surfaces, they will cause more friction.

Challenge:
Students will evaluate the varying friction of materials. Which material will slow a toy car the most? Which will slow a toy car the least? Why?

Time: 45 to 120 minutes - depending on number of trials

Procedure:
Classroom management: Divide your students into groups of four. Before class, place the pieces of "friction" materials in separate piles.

Introduction: Explain to students that today they will get to experiment with toy cars!! Ask them what type of experiments could be conducted with the cars. Tell them their ideas were great! Do not tell students about friction at this time. Allow them to discover its effects! Set up cooperative groups.

1. Explain that one experiment they can conduct involves letting a single car move down a ramp and measuring the distance the toy moves along the floor. Ask student groups to first construct their car ramps. Any height is fine.

2. In each group there should be one person who is in charge of letting the car begin its journey down the ramp. Another person should hold the ramp so it is steady. A third person should place different materials at the end of the ramp for each

run. A fourth person must measure the distance the car travels and record data (distance traveled on floor, type of material at end of ramp, and description of car). Data is to be collected using all five toy cars and a variety of friction materials.

3. After students have collected all data, ask them to decide what the effect of the differing materials were on the distance one particular car traveled.

3. Following a discussion of the distance one particular car traveled down the ramp, ask students to look over their data to determine whether or not the other tested cars were slowed down in the same way as the first car. For Example, if the shag rug resulted in the smallest distance traveled by the first car, was this the case for all of the other cars?

4. After all data has been discussed students should be able to conclude that particular materials slow all of the cars down more than other materials. Students will have an intuitive feel for the "slowing down" which is caused by friction. Explain to them about the term "friction" and that it is the same as the "slowing down" they saw on their cars. Use the paper and washboards analogies (or other ones along the same line) to better explain the causes of friction.

Wrap up: Ask each student group to discuss among themselves what effect friction might have on their lives. When might friction occur? Ask students how they might explain friction to younger students.

Assessment:

Present students with additional "friction" materials. Instead of collecting data with these materials, pupils could be asked to predict which material would cause the greatest amount of friction. Ask students to justify their selections.

Connections:

Mathematics: Ask students to create a formula (relationship) to express the amount of friction created by each material.
Social Studies: Oil is a lubricatant. What would be the effect on society if we did not have oil for lubrication? What if we suddenly had no materials to reduce friction in engines?

Reference:

Science Horizons: Grade 5 TE. (1991). Morristown, NJ: Silver Burdett and Ginn.

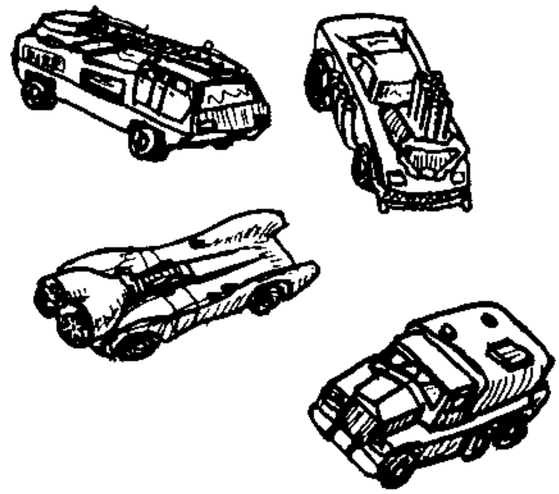
Q Did your car travel in a straight line?

Q How did you measure the distance your car traveled?

Q What variables must be considered as you conduct your tests? (the height and construction of the ramp, the path each car took down the ramp, and the accuracy of measurements)

Q If the distance traveled was effected by the material at the end of the ramp, what characteristics of the material could cause this difference?

Q What is similar about each groups data? What is different?



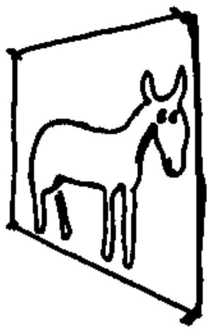
The Author:
Dr. William J. Boone is an Elementary Science Education Coordinator for the School of Education at Indiana University in Bloomington, IN.

28 Donkey Pinning

By: Vicki Ellingsworth

Materials:
For each group:
a Pin the Tail on the Donkey Game
a scarf or half mask with covering over the eyes
pins or tape

Safety Note: A corner of the room should be cleared of desks etc to prevent student falls or bumps. Warn students about careful use of straight pins.



Q Was your prediction correct?

Q Can you think of anything you could have changed to make it more accurate?

Q Did your findings change the second time?

Focus: A Pin the Tail on the donkey game will be used as a probability activity. The children will predict how many times the pin will hit the donkey.

Challenge:

Can you predict how many times the pin will hit the donkey? What factors effect whether the pin hits the donkey?

Time: one class period.

Procedure:

1. Introduce the term probability as a technique used by scientists, and others, to predict the times or chances something will happen or reoccur.

2. Attach the picture of the donkey on a wall or smooth surface free of holes or pins.

3. Place students in teams of 3. One student will record, one will turn the student that is masked, and the other will be masked. Children will take turns in each role.

4. Have students make a chart for their information. They should record predictions, tester, and where pin lands.

5. All students predict if the first blindfolded person on the team will place the tail on the donkey. This may be given as accuracy: hit; close= 2-3 in.; far = over 3 in. One student is blindfolded, turned twice, and places a tail on the game. The record keeper lists student name and accuracy level.

6. The turner and the student blindfolded change places and repeat the procedure. This continues until all three students have had 2 turns.

7. Ask that students tally their results and make a graph

showing each students results.

8. Have student teams analyze their results.

Assessment: The graphs the student groups plotted and the discussion of the questions would evaluate their understanding of probability.

Further Challenges:

•If you were to do this activity again, what would you change?
•Can you think of another activity you could do to test for probability?

Connections:

Mathematics: Introduction to graphing or averaging.

References:

Principals of Science. New York: Merrill Publishing Co.

The Author
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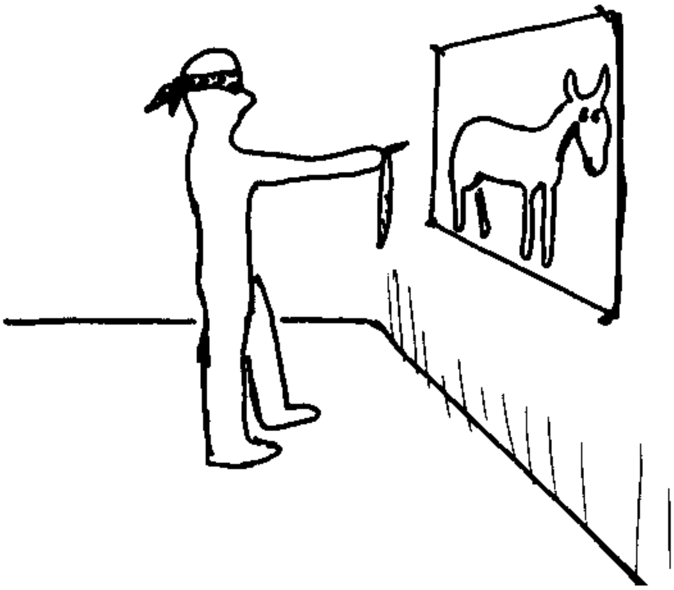


29 Silly Putty Pickups

By: Tom Runyan, Alison Dowd, and Jerry Sarquis

Focus:

Silly Putty is a polymer that exhibits unusual behavior such as its ability to bounce and to stretch if pulled slowly but to snap if pulled rapidly. This is because relatively weak cross links exist between adjacent polymer chains. These cross links can be easily broken when a stress is applied. Bouncing causes some cross links to break but those remaining intact cause the Silly Putty to regain its original shape. Stretching applies stress for a longer time and will break more of the cross links so the original shape is not regained when the stress is removed. A more extensive discussion of the mechanical properties and the chemical structure of Silly Putty can be found in the ChemMatters article listed in the references. Silly Putty is an oil-based polymer that is nonpolar in nature. As a result, it readily picks up inks used to print newspapers and comic and telephone books. These inks are made from mineral oil and various pigments. The pigments are relatively insoluble in water which is a polar molecule but can be applied as inks using nonpolar mineral oil as the base. The oil based inks dry
slowly and their pigments are attracted to the excess oil in the putty. This also explains why newsprint often comes off on our skin which is also oily.

Materials:

each group of students will need:

Silly putty™
scrap paper

variety of printed materials such as:
newsprint
comic books
photocopies
magazine pages
computer print
typewriter print

variety of ink pens such as:
permanent markers
ball point pens
felt tipped markers
overhead projector pens

Challenge:

Students will explore the properties of Silly Putty™ and the types of print and picture inks that can be picked up by Silly Putty™.

Time: 35 - 55 minutes

Procedure:

Part A - Silly Putty™ Pickup Test

1. Working in groups of 2-4, have students test a variety of inks from printed materials and pens.
2. After a period of 10-20 minutes, ask each group for a summary statement of their findings.
3. If polyvinyl alcohol slime is available, have students contrast its behavior toward inks with that of Silly Putty™.

Q What differences are there in the ability of Silly Putty™ to pick up ink from different printed materials and pens.

Q What happens when you run your own fingers across newsprint?

Part B - Silly Putty Property Investigation
4. Working in groups of 4, allow students 10-20 minutes to examine the properties of Silly Putty.

Part C - Stretching and Snapping Demonstration
5. Pull the Silly Putty slowly so that it stretches and quickly so it snaps.

Q What properties of Silly Putty™ did you observe?

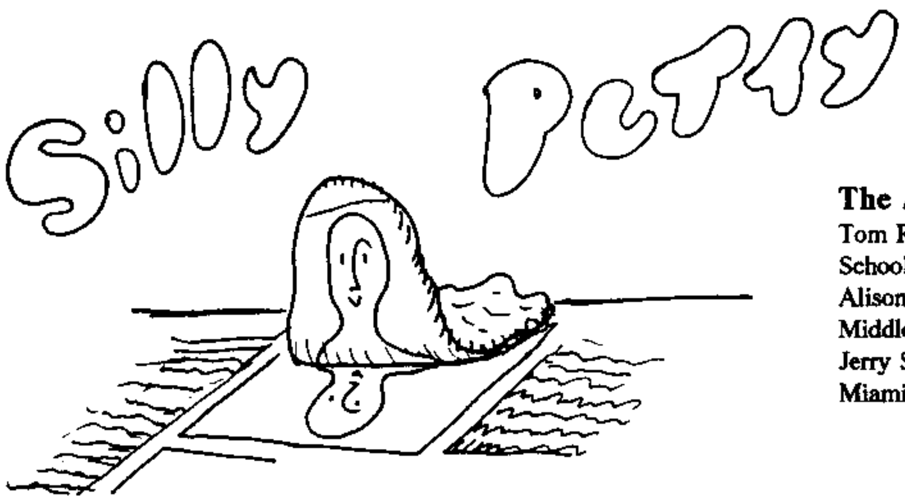
Q Why do you think Silly Putty™ acts so differently under sudden versus slow stress?

Further Challenges:
•Challenge students to design their own ink especially for Silly Putty™ "Pick-Up" pictures.
•Do the properties of Silly Putty change when the temperature changes?

Assessment:
Ask students to list reasons for calling Silly Putty™ a solid and reasons for calling Silly Putty™ a liquid.

Connections:
Ask students to think of uses for Silly Putty™ other than as a toy.

References:
Armitage, D.A., et al. (1973). The Preparation of Bouncing Putty: An Undergraduate Experiment in Silicone Chemistry. *Journal of Chemical Education*, 50(6), 434.
Casassa, E.Z., Sarquis, A.M., and Van Dyke, C.H. (1986). The Gelatin of Polyvinyl Alcohol and Borax. *Journal of Chemical Education*, 63, 57.
Marsella, G. (1986). Silly Putty. *ChemMatters*, 4(2), 15.
Sarquis, J.L.and Sarquis, M. *Fun With Chemistry: A Guidebook of K-12 Activities*. Madison, WI: University of Wisconsin.



The Authors
Tom Runyan teaches at Monroe High School in Monroe, OH.
Alison Dowd teaches at Talawanda Middle School in Oxford, OH.
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30 Shooting the Grove

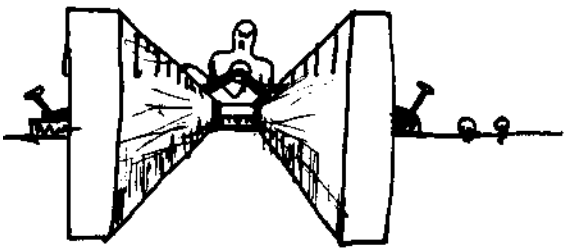
By: Karen Combs, Steven Kibler, and Janet Myers

Focus:

To determine whether a ball with a larger mass will travel a greater distance than one with lesser mass, keeping all the other variables the same. By using a rubber band attached to a stationary piece of wood and with two meter sticks placed at a right angle serving as a chute, a rubber ball 3 cm in diameter will be propelled.

Materials:

For each cooperative group:
various sizes of rubber bands
2 nails
length of wood (app. 100 cm x 12 cm x 1 cm)
4 rubber balls each 3 cm in diameter and having different masses
2 meter sticks
masking tape
hammer
metric scales



Q Why is it important to use more than one trial for each ball?

Time: 2 class periods of 40-60 minutes

Procedure:

Classroom Organization: Place students into groups of four. One student reads and gives information to a recorder. Third student performs game activities and the fourth student monitors. This could be done outside on a flat surface such as a blacktop or sidewalk, or inside on a floor with sufficient room.

Introduction: Demonstrate how to set up the activity. Explain to students the idea behind this activity. The activity will be used to measure the distance an object (rubber ball) can be propelled, by using a rubber band attached to two nails upon a stationary piece of wood with two meter sticks placed at right angles serving as a chute. The object is to see how far a given rubber band can propel a rubber ball of a set diameter but with varying mass. Students can propel the four rubber balls of different masses four times each to get an average distance.

1. Have students create a data table. The table should include the mass of each ball (massed prior to using it).

Distance Traveled	trial 1	trial 2	trial 3	trial 4	average
Ball mass 1					
Ball mass 2					
Ball mass 3					
Ball mass 4					
Ball mass 5					

2. Discuss the variables that will be controlled in this investigation. List them on the board. Lead students to understand that they must carefully control the variable of force.

Q How can you control the variabe of force?

3. Before starting this activity the students should each predict what they think will happen and why. This information should be compared with the end results and conclusions made.

Assessment Tool:

Have students graph the mass and average distance of travel for each ball on a line graph. Ask them to predict the distance a ball would travel if it were twice as heavy as the heaviest ball used in the investigation.

Further Challenges:

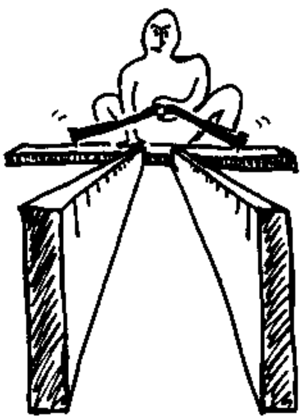
•Determine what effect the rubber band has on this investigation. What happens if you use a thinner rubber band? a heavier rubber band? ....another type of elastic material like a balloon or piece of tire rubber?

References:

DeVito, Alfred and Krockover, Gerald. (1980). *Creative Sciencing*. New York: Little, Brown and Company.

Malone, Mark (Ed.). (1987). *CESI Sourcebook V: Physical Science Activities for Elementary and Middle School.* Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Radford, Don. (1981). *Science, Models, and Toys: Science 5/13.* Milwaukee, WI: Macdonald-Raintree Inc.



The Authors

Karen Combs teaches in McLeansboro, IL.

Steven Kibler teaches in Dieterich, IL.

Janet Myers teaches in Charleston, IL.

31 Let the Ruler Races Begin

By: Rita Hunt

Focus:

This activity adds to the procedures of scientific inquiry using the very common student activity of spinning their rulers on their pencils. Students will be asked to observe, predict, and infer. A sample question will be given to provide an example of experimental design. Students will collect data, use a data table and analyze their results. This analysis should lead to more questions as in any scientific inquiry.

Materials:

Each student will need:
30 cm ruler with a small hole in the center
sharpened pencil
data table
Each group of two students will need:
cup of clay, plaster of paris, or play dough
stop watch or other timing device that counts seconds
Class table and graph master (large paper, chalkboard or on the overhead)

Safety Note: Warn students to be cautious and keep their ruler on the pencil. A runaway ruler must, of course, be disqualified.

Challenge:

Investigate the spinning of a ruler.

Time: One or two class periods.

Procedure:

Introduction: Explain to students that they already know the best thing to do with a ruler and a pencil. "You are to carefully stick the point of the pencil into the center hole of the ruler, hold the pencil in vertical position, and give the ruler a solid but controlled push with the other hand. The ruler goes round and round and round...fascinating. You have discovered something interesting and you are observing it. And while you are observing it you are thinking of questions..." Why does it keep going so much longer than other things I spin? How can I make it spin longer? If a flea wanted a free ride, and he sat down in the" 0" on the ruler, how far do you think he would travel in one time around? About how fast do you think he would be going? Would it be easy for him to stay on or would you have to provide him with a seat belt?

1. Observe. Ask students to practice accelerating their ruler with one push. Watch it. Wait till it stops. Try it again. Push different ways. Try pulling it. Explain that they are the force acting on the ruler. When they think of a question it should be written it down.

2. a. Predict. Explain that one question suitable for a controlled experiment is: How long can we keep a ruler spinning with one push? A prediction might be: The longest we can consistantly keep the ruler spinning with one push will

be 15 seconds.

b. Design Experiment. Explain that the experiment will help answer questions and prove the accuracy of predictions. Questions always come up when conducting and designing an experiment. A scientist tries to control as many variables as possible while varying one to measure its effect on the system.

3. Place students in teams of two.

a. Have them set up the system: place the pencil in a small cup of clay, play dough, or plaster of paris to hold the pencil straight and steady.

b. The team should choose who will be the timer and who will be the force that starts the ruler spinning.

c. Conduct timings. The timer will say, "Ready, go." On "go" the force will give the ruler a controlled push. The timer will begin timing on the word "go" and will watch the clock or start the stop watch. The force watches the ruler, and when the ruler stops, he will say, "Stop." The timer figures the length of time from the words "go" to "stop" (which is how long the ruler has spun) and records it on a data table that is set up ahead of time. This will be repeated five times.

c. Finally, the timer and the force will change jobs and complete a second data table.

SPIN	DURATION OF ROTATIONS IN SEC.
1	
2	
3	
4	
5	

4. Organize data. For the purposes of classroom comparison have students compute the average time (length of time of rotation) for both tables.

5. Analyze data. Bring the class together and make a class table and graph. What was the fastest average time? Is there a clear cut winner? Has the person a reputation of ruler spinning? Is it the skill of the spinner? The type of ruler? Type of pencil? How could you test this? Can a good spinner teach this skill to others? Or...are the results basically the same? Why do you think that happened? What ways can you think of to make the rulers spin longer?

Challenge:

•Choose one of your questions and follow scientific procedures to discover the answer.

Q How do you push the ruler and keep track of the time?

Q When do you start counting time?

Q How do you hold the pencil up straight?

Q How can we verify consistency?

Q Why are the tests repeated five times each?

Q How do you compute average time?

The Author
Rita Hunt is a third grade teacher at Clay City Elementary School in Clay City, IL.

32 Quack, Duck, Quack!

By: Ruth H. Stehman

Focus:

Sound is a form of energy that is produced by vibrating matter. It travels outward in all directions from its source. It can travel through all kinds of matter - solid, liquid or gas. While sounds are alike because they are formed by vibrating matter, there are also differences in sounds. Sounds may be high or low, loud or soft, useful or harmful. Some sounds are called noise. Noise can have an adverse effect on people in the environment by causing noise pollution.

Materials:

for each student in the class:
1 seven or nine inch paper cup
piece of string (60 cm. long)
one inch brass fastener
2 eyes, 1 beak, 1 feather
paste
1 piece of dry paper towel (6cm. by 6cm.)
Small cup of water for each table or each row of desks.

Advance Preparation:

Put a hole in the bottom of each paper cup with a pencil.

EYES

FEATHER FOR TOP

Challenge:

Students will construct a toy duck noisemaker. What kinds of sounds can the toy duck produce? Would you classify the sounds as pleasant or unpleasant?

Time: one class period of 30 to 40 minutes

Procedure:

Classroom Management: Large group with desks or tables for the children to use to construct the ducks.

Introduction: Read the story "The Ugly Duckling" to the class. Ask the children to think about the sound a duck makes. Do they like the sound a duck makes? Would they classify it as pleasant or unpleasant? Following the discussion about sound, inform the children that they will now make a toy duck noisemaker for the purpose of investigating with some sounds.

1. Distribute materials and make the duck.
   a. Turn the cup bottom side up. This will be the top of the duck's head. Paste the eyes and beak on the cup (see illustration).
   b. Wrap the string around the brass fastener under the round top and tie string securely with a knot.
   c. Pull the string through the hole in the cup from the inside to the outside of cup. The paper fastener will be in the bottom of the cup. Reach into the cup and open the paper fastener.
   d. Add the feather to the duck's head.

2. Begin the investigation. With the duck in one hand, have students use the piece of dry paper towel to pull along the

length of the string. Note the sound it makes. Does it sound like a duck?

3. Have the children wet the paper towel and again pull it along the length of string. Now does it sound like a duck? Would you classify the sound as pleasant or unpleasant?

4. For a period of about ten minutes permit the children to experiment with making different sounds. Encourage them to work together and to discuss their findings with each other.

Wrap-up: Discuss with the children the different sounds they were able to produce. How did they feel about all the noise? What kinds of problems do they think noise could create?

Assessment:

Teacher observation checklist:
•Science vocabulary used by the child.
•Extent of experimentation to produce different sounds.

Further Challenges:

•What effect do you think using other materials such as milk cartons, styrofoam cups, plastic cups, etc. would have on the sounds made?
•Instead of wetting the paper towel with water, how do you think that using vinegar, oil, mayonnaise, soda, flour, or other materials would affect the sounds made?
•What effect do you think you would hear if the cup were larger? smaller?

Connections:

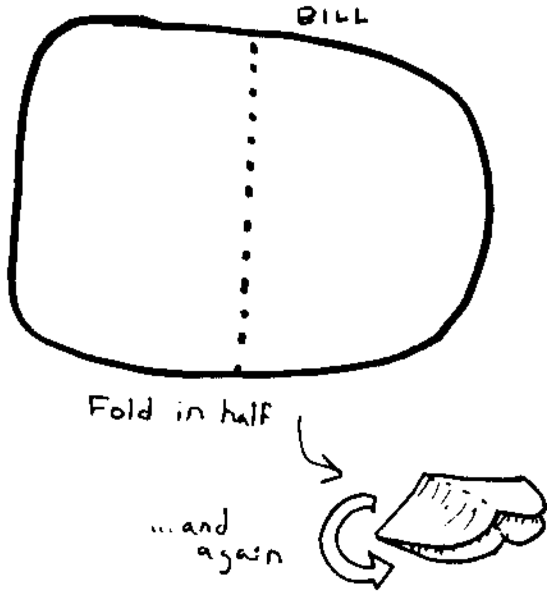
Art: Make a poster showing harmful noise pollution.
Language arts: suggestions for journal writing.
•Write step-by-step directions for making the duck.
•Tell how you think the toy duck makes the sounds.
Social Studies: List jobs where people may be affected by harmful noises.

References:

Broekel, Ray. (1983). *Sound Experiments.* Chicago: Children's Press.
Knight, David. (1975). *Let's Find Out About Sound.* New York: Franklin Watts.
Sootin, Harry. (1964). *Science Experiments With Sound.* New York: W.W. Norton Co.

Q Is it easy to pull the dry paper towel down the string? What do you feel?

Q Is it easy to pull the wet paper towel down the string? What do you feel?



The Author
Ruth H. Stehman is a teacher at Mountville Elementary School in Mountville, PA.

33 Buttons on a String

By: Debra Dougherty and Terry Fear

Materials:
For each student:
18" 100% cotton string
assortment of 4-hole buttons of approximately the same weight in various circle diameters;
For each group:
prepared data table
centimeter rulers
stop watch
diagram for labeling

Focus:

Through this activity students will have hands-on experience reinforcing the scientific concepts dealing with vibration. This simple toy illustrates:
•VIBRATION - any sustained motion in which an object moves back and forth about an equilibrium or rest position:
•NODE - the midpoint of a sound wave where there is no vibration (the button)
•PERIOD - time for one complete round trip of a vibrating body (the button causes the string to vibrate; the string moves the button; this round trip would be one period)
•CENTRIFUGAL FORCE - an object tends to move to the outside of a rotating disc.
•DIAMETER - greater diameter provides greater centrifugal force.
•VARIABLE - a controlled change in an experiment.

Challenge: Can you simulate a soundwave?

Time: one or two class periods

Procedure:

Classroom management: Set up cooperative groups.

a. recorder/timer
b. twirler/counter
c. (observer-optional)

Introduction: This toy is good for a culminating activity following a science book lesson on vibration. Review vocabulary and share diagram labeling each part as it illustrates a vocabulary word. Review of co-operative group rules/roles.

1. Prepare the toy, each group will have 4.
   a. cut one piece cotton string 18" long.
   b. Thread string through 2 diagonal holes and knot
   c. Hold string at each end and position button in the center of the string (see illustration).

2. Prepare data table: constants are lengths of string, shapes of buttons, number of twirls (20), and length of time (30 sec./

button); variables are diameter of buttons and number of periods. Button diameters are measured and recorded on data table.

3. Have students predict the outcome: which button will produce the most periods? Have them record their predictions.

4. Practice the method to be used. Be sure students are clear about the definition of "period" and are counting the rotational motion.

5. Ask students to follow this procedure to collect data:
   a. "Twirler/Counter" will twirl thread 20 times
   b. "Recorder/Timer" will begin timing for 30 sec. as Twirler/Counter releases/works toy and counts periods.
   c. Periods are recorded on data table.
   d. Repeat steps 5-8 for different buttons.

Q How many times should one toy be tested in order to collect accurate data?

6. Have student groups analyze their data and answer the following questions.
- Can you identify any pattern in your data table?
- Compare your prediction with your outcome.
- What affected the outcome?
- What other predictions can you make?
- What variables could you change to test your ideas?

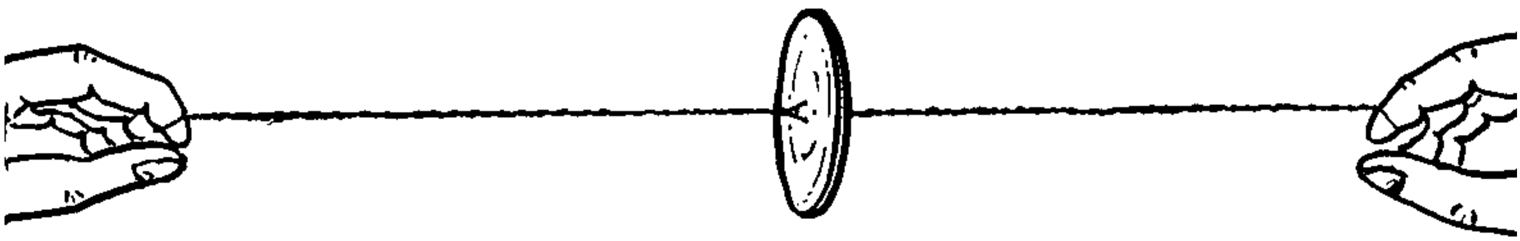
Assessment:
Students may be informally assessed through teacher observation of group work.
Formal assessment through vocabulary quizzes and/or diagram labeling.

Further Challenges:
- What simple or complex machines in the real world share these concepts of vibration?
- How could you reduce/increase vibration?

Q Why would you want to reduce/increase vibration?

Connections:
Art: Draw your toy as part of an invention or as a part of a piece of art or as part of an instrument.

The Author
Debra Dougherty is a Chapter I Reading Teacher at Newton Central.
Terry Fear is a third grade teacher at Grove Elementary in Newton, IL.



34 Pinwheels

By: Carol Van De Walle

Focus:

The simple pattern for a pinwheel will serve as a means to test variables. Students will be able to decide upon the best type of paper and the best size as they test the efficiency of the pinwheel. They will also discover the need to operationally define "spin" for the purpose of the activity. They may also try to develop a better pinwheel by modifying the pattern.

Materials:

Each student will need:
newspapers, several sheets
scissors
1-2 straight pins
pencils with erasers
ruler
pattern for basic pinwheel
The class will need:
assorted weights of paper
tape, masking or clear for each 3-4 students
fan, optional

Safety Note: Students should be cautioned about the safe and appropriate use of straight pins. If accidently pricked, the pin should be discarded in a "medical sharps" container (usually the nurse will have one of these).

Challenge:

Can you determine the best spinning, largest, and smallest working pinwheels using only newspaper and the basic pattern for the pinwheel?

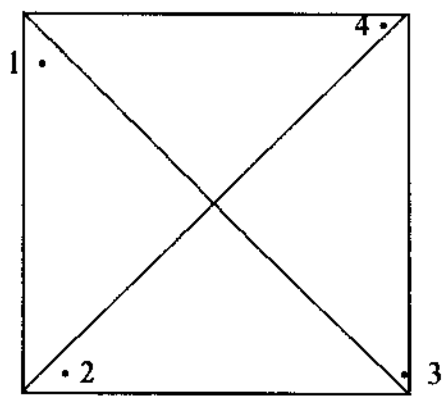
Time: 2-3 class periods

Procedure:

Classroom organization: Students will work individually on this project, but it is helpful to work with a partner when taping the pinwheel. This project also lends itself to using cooperative learning groups. When working on the very large pinwheels an area on the floor is best.

1. Pose the challenge questions to the students. Discuss the term variable.

2. Have the students observe and discuss the pinwheel pattern. They should notice it is a square with alternating points, on the cut sides, labeled.



3. Have all students make a medium sized pinwheel to serve as a model. Some students, especially younger ones, may have difficulty following the pattern, it may be helpful to direct the entire class through the construction of the model. If using written directions for students to follow, allow them to work in cooperative groups.

4. For pinwheel construction each student should
•cut a 15 cm square from their newspaper.
•place numbers and dots on the newspaper pinwheel as shown on the pattern.
•cut out the pinwheel.
•bring the corners with the dots to the center.
•tape them to the center and insert the straight pin through all layers.
•put the straight pin, the pinwheel attached, into the side of the eraser on the end of the pencil

Q What do you need to do if your pinwheel is not spinning freely?

5. Blow on the pinwheel. It should spin freely. Adjust.

6. Challenge students to make the largest and smallest possible pinwheels that will spin. Discuss sizes that worked. Have students with the largest and smallest pinwheels demonstrate.

Q What is the largest pinwheel you can make? The smallest?

7. Discuss and list variables that may account for one working and another of the same dimensions not working. Discuss ways to control these variables. For example, a fan can be used to control the amount and speed of air.

Q Which variable effects the pinwheel motion the most?

8. Students should control the other variables and change the type of paper used. Have students determine the variables to be controlled.

9. Have students operationally define the "best" pinwheel spin. Compare the results of each student group. Can they come to a consensus about the best material?

Q What characteristics does the "best" pinwheel have?

Connections:

Math: Use shapes other than a square to try to make a pinwheel. Label the shape used and if it was successful.
Language Arts: Write an advertisement for your pinwheel or create a bumper sticker to encourage others to make pinwheels.

Q Why is it important to control variables in an experiment?

Reference:

Dalheim, Mary (ed). (1982). *Foolproof, Failsafe, Seasonal Science.* New York: Instructor Publications Inc.

The Author
Carol Van De Walle is a teacher at Alwood Elementary School in Alpha, IL.

35 Making a Density Bottle

By: Jerry Sarquis, Alison Dowd and Tom Runyan

Focus:

Substances have characteristic densities and their molecules can be categorized by their polar and nonpolar nature. A polar molecule behaves like a particle having oppositely charged ends and a nonpolar molecule behaves as if there were no regions of charge on the molecule. Molecules have attractions for other molecules and these attractions are influenced by the polar or nonpolar nature of molecules. The rule of thumb "like dissolves like" refers to the polar or nonpolar nature of molecules. If two liquids are both polar or both nonpolar, they will generally dissolve in one another to form a homogeneous mixture (a solution). If a polar substance is mixed with a nonpolar substance, they generally do not mix. If the two substances have different densities, one will layer upon the other. Even after mixing, the two liquids will separate into two layers if allowed to stand. When a substance is added to layered liquids that do not mix, the third substance will tend to dissolve in the layer it is most "like." For example, if a polar substance is added, it will dissolve in the polar layer and if a nonpolar substance is added, it will dissolve in the nonpolar layer.

Materials:

Each group of students will need:
1 liter, colorless plastic soda pop container*
500 mL water*
500 mL vegetable oil or mineral oil*
water soluble food coloring
oil soluble Easter egg dye (optional)
* Note - smaller amounts may be used with smaller container; the proportions are important but the amounts are not.

Challenge: Students will make a density bottle by mixing water and oil. They will investigate the relative densities of the two liquids and the polar or non polar nature of a dye that is added to the density bottle.

Time: 25-40 minutes

Procedure:

1. Prepare one or more density bottles ahead of time according to procedures described below and show it to the students. Ask them to make observations and make a hypothesis as to the identity of the 2 substances in the bottle.

2. Have each group of students fill a plastic bottle approximately half-full with oil. Next fill the bottle by adding water then cap the bottle.

3. Have students observe and describe what happens to the two layers and discuss why.

Q How many layers do you see?

Q Why are the layers present?

Q What would happen if the water was added first?

4. Ask students to try mixing the two layers by inverting the bottle several times. Tip: Caution the students not to shake the bottle too vigorously; an emulsion that is slow to separate can form.

Q Is the same layer always on top?

5. Discuss the concept of "like dissolves like." Explain that water is a polar molecule and oil is a nonpolar molecule.

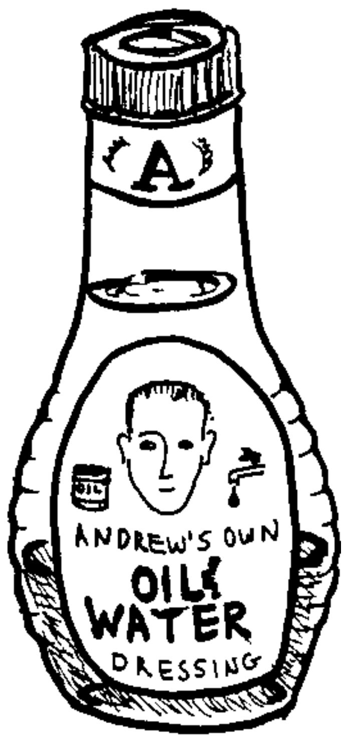
6. Have students add a few drops of food coloring or another dye. If water soluble and oil soluble dyes are both available, have different groups use different dyes. Be sure students observe which layer the food coloring ends up in. (It will be the bottom water layer if the dye is water soluble and the top oil layer if oil soluble.) Have the students infer if the dye is "like" the oil or the water. Ask them to give reasons to support their inference.

Q Which layer do you think the dye will dissolve in?

Q Is the dye used "like" the oil or the water?

Q Is the dye used polar or nonpolar?

7. Have the groups discuss their observations, inferences, and rationale with the class.



Assessment:

Explain why you need to shake oil and vinegar salad dressing just before you use it.

Further Challenges:

•Change the order of addition: add oil, water and dye; add dye, water and oil; add dye, oil, and water. Compare the results.
•Gently shake a bottle and while other students shake more vigorously. Do the layers still separate? How long does it take for the layers to separate (use a timer to determine the difference in rate)?
• Name other materials that don't mix and have different densities. Oil and vinegar salad dressing and motor oil and water are two possibilities.
•Make a density bottle using other household liquids of different density such as liquid detergent and water or honey and water. Is the order of addition important? What happens when the bottle is inverted several times? Do the layers mix? Do the layers separate after mixing?

References:

Sarquis, A. M. and J.L. editors. (1991). *Fun With Chemistry: A Guidebook of K-12 Activities*. Madison, WI: Institute for Chemical Education. 119-122.

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36 A Pinpoint of Light

By: Carol Etzold

Focus:

As light energy travels through air, it moves in waves which do not bend - these waves can travel only in perfectly straight lines. They can bend when they move from one medium to another. We see images of the objects around us because the light waves which have traveled from the sun or another light source have hit those objects and bounced in straight lines to our eyes. We do not see the light waves that have bounced off in other directions. This activity is intended to be used after students have had several other experiences with light. It is not an introduction to light rays but rather, a way to apply knowledge.

Materials:
for each viewer:
1 paper towel tube or 2 toilet paper tubes
1 cardboard tubeslightly smaller in diameter (ie: gift wrap tube)
1 square wax paper approximately 3 x 3"
1 square aluminum foil approximately 3 x 3"
masking tape
scissors
pin

Challenge:

Construct a viewer that will enable you to see objects upside-down. Then explain why your viewer can do this.

Time: 1 class period of 40-60 minutes

Procedure:

1. Have each student construct their own viewer.
•If necessary, join the ends of the 2 toilet paper tubes together to form one long tube. Tape around the 2 tubes smoothly so that there are few bumps on the tape and the seam is fairly stiff.
•Place the square of wax paper over one of the ends of the long toilet paper tube.
•Wrap tape around the sides of the paper on the tube so that the paper lies smooth and flat. Avoid wrinkling the wax paper, and cut off any wax paper that lies below the tape on the sides of the tube.
•Place the aluminum foil square over an end of the paper towel tube. Tape it in place in the same manner, being careful not to get any holes or tears in the foil.
•Make a small pinhole in the center of the foil.
•Insert the narrower tube inside the paper towel tube, keeping the open ends of both tubes toward you. You should be able to slide the inner tube up and down inside the outer tube.

2. Direct students to begin observations. Have them close one

eye while holding the open end of the small tube up to the open eye. Point the viewer at a very bright, preferably colorful object or area, such as a light fixture or sunny outdoor scene. Slide the outer tube up and down slowly until a small, relatively clear image can be seen on the wax paper screen.

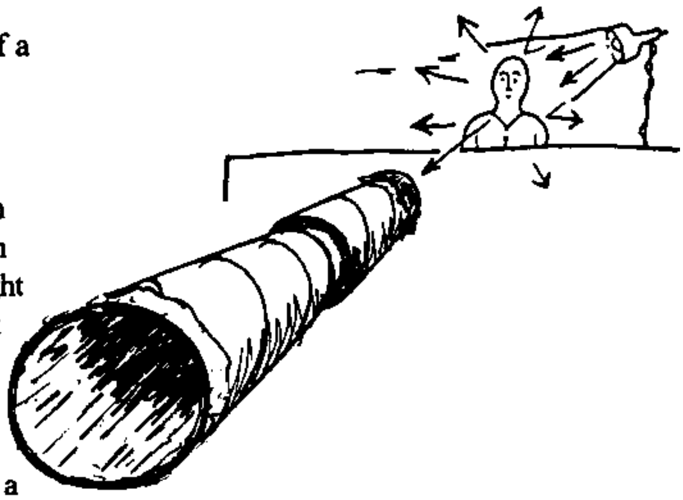
3. Focus the viewer on a moving object, such as a car or a walking student.

4. Focus on a still object. Slide the outer tube out slowly. Predict what will happen to the image on the screen if a second pinhole is made in the foil. Test the prediction. How would you expect the image to change if the pinhole is enlarged? Find out by gently enlarging one of the holes with the side of a pin.

Q What colors does the image have? Is it right-side up or upside-down?

Q Does the image move in the same direction as the object?

Q How does the size of the image change? It's brightness?



Assessment:

Draw a line diagram of the pinhole viewer as it appears from the side. Then draw lines to show the path of light rays from an object through the viewer to your eye. Remember, all light rays reaching your eye travel only in straight lines, and must pass through the pinhole.

Further Challenges:

•Based on the pin-hole viewer, design a simple camera from a shoe box or large carton so that a piece of black and white film could be placed in the position of your eye. Use the camera to record an image on the film.

•Make a giant viewer, a camera obscura, of a room or large closet in your school. You need to find a room with a sunny exposure and a ground-level view. Darken the room, using opaque paper, plastic or cloth over all windows and other light sources. Make a hole, approximately 1" square, at eye level in the center of the window covering to allow light to enter. Hang a sheet or place a movie screen facing the hole approximately 8 to 12 feet from the window. Standing between the screen and the window, look for an image on the screen. If the image is blurry, adjust the placement of the screen. Ask 2 or 3 students to go outside the window and "perform" for the viewers indoors. Simple movements such as walking, waving or jumping jacks are particularly effective.

Reference:
Schmidt, Victor E. and Rockcastle, Verne N. (1968). *Teaching Science With Everyday Things*. New York: McGraw Hill Inc.

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37 A Slimy Experience

By: Carol Etzold

Focus:
Many everyday products such as styrofoam, soda bottles and running shoes are made of polymers. Polymers are huge molecules consisting of many repeating parts which are linked together to form chains. The chains may be cross-linked by other atom groups into a net. The more cross-links, the stiffer or more rubbery the polymer, the fewer the cross-links, the more liquid-like or flexible the polymer. While many polymers occur naturally, such as latex and gelatin, many are man-made, such as polystyrene and acrylics.

Challenge:
Follow simple recipes to create two different slimy polymers. Then investigate some of the properties of these molecules by comparing and contrasting the properties of the two slimes.

Time: 2 class periods

Procedure:
Classroom management: Students should work in pairs, sharing sets of materials and equipment, but each student would make the 2 types of slime.

•To make guar gum slime:
1. Measure 100 mL. of water into a mixing cup. Add food coloring and stir.
2. Measure 1/8 tsp. of guar gum, and, while stirring constantly with a wooden stick, add it gradually to the water. Continue stirring for about one minute, until all the guar gum has dissolved and the solution has become slightly syrupy.
3. Add 1 tsp. Borax solution to the mixing cup while stirring constantly, the mixture will thicken quickly, but continue stirring until most of the liquid has been absorbed. Then remove the slime from the cup and knead it with your hands.

•To make the sodium borate solution:
1. Measure 100 mL. of water into a cup marked "borax".
2. Add 1 tsp. Borax to the water and stir for one minute, or until all of the white powder has dissolved and the solution is clear.

Materials:
For the Sodium Borate solution
(makes enough for 2 people)
1 tsp. Borax (sodium borate)
100 mL. warm water
1 wooden craft stick for stirring
1 6 or 8 oz. paper or plastic cup for mixing, marked "borax"

For the guar gum slime
(makes enough for 1 person)
100 mL. warm water
2 or 3 drops of food coloring
1/8 tsp. guar gum
1 tsp. sodium borate solution
1 wooden craft stick for stirring
1 6 or 8 oz. paper or plastic cup for mixing
1 sandwich-size zip-close baggie for storing slime

For the gluep
(Makes enough for 1 person)
1 tbs. Elmer's type white glue
1 tbs. water
1 or 2 drops food coloring*
2 tsp. sodium borate solution
1 wooden craft stick for stirring
1 6 or 8 oz. paper or plastic cup for mixing
1 sandwich-size zip-close baggie for storing slime

Lab tip:
Slime is non-toxic but is difficult to remove from fabric. If it does stick to clothes, dissolve the slime with vinegar and rinse with water. If left on wooden furniture, it will leave a water mark.

•To make gluep:
1. Measure 1 tbs. glue into a mixing cup. Add 1 tbs. water and 1 or 2 drops of food coloring and stir to blend.
2. While stirring constantly, gradually add 2 tsp. Borax solution. When the mixture thickens, remove it from the cup and knead it with your hands.

Wrap-up: Have students compare the properties of the two substances they have made. Ask for them to list qualities of the slime. Can it bounce? stretch? pick up images off newspaper? Each partner team should construct a data form to compile information on each slime.

Q In what ways are the two products similar?

Q In what ways are the two products different?

Further Challenges:

•Think of ways to modify one of your slimes by changing the recipe in some way. For example, how could you change the recipe to produce a more rubbery guar gum slime? Make a prediction and test it.
•What other substances share some of the same properties as one or both of the slimes? Are they chemically related in some way?

Notes: The hardness and warmth of the water seems to affect the outcome of the slimes. Experiment with differing proportions of ingredients until you produce slime of desired consistency.
If you are not using the slime immediately, store it in a refrigerator to prevent mold growth.

Reference:

Malone, Mark (ed). (1987). *CESI Sourcebook V: Physical Science Activities for Elementary and Middle School.* Columbus, OH: ERIC Clearing House for Science, Mathematics, and Environmental Education. 236.
Ukens, Leon (ed). (1986). *Science Experiences for Preschoolers: CESI Sourcebook IV.* Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education. 32.

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38 "Magic" Sand: A Surprise in Water

By: John Williams, Jo Parkey, and Sue Ehrlich

Materials:

for advance preparation:
1-2 cups clean, fine sand
silicone spray
1 shallow box
newspaper

per work station:
container of sand - regular, commercial magic or home-made magic
2 - L soda pop beaker of water
small dish
eyedropper
spoons and/or utensils
newspaper

clean-up:
pan
paper towels or coffee filters
rubber bands
soda pop bottle

Advance preparation:

Make home-made magic sand by sprinkling sand in a THIN layer on newspaper that is spread out (without gaps) up and over the sides of a box. Thoroughly and evenly silicone spray the sand, then shake the box to coat all surfaces of the sand: allow 1-2 days to completely dry. (Check that the sand functions properly in water; if not, repeat treatment.)
Set up stations as numbered.

Safety Note:

Avoid inhaling the spray fumes by DOING OUTSIDE and following the directions on the can. Caution students not to taste the colored commercial magic sand (it may be mistaken for candy!) Save sands for reuse; dispose of spills in trash. Do not put magic sand into an aquarium—it may kill the fish!

Focus:

Two or more substances combine together to form a mixture, either homogeneous (in which its properties are uniform throughout) or heterogeneous (in which its properties are not uniform). The type of resulting mixture is dependent upon the nature of the actual particles. A heterogeneous mixture occurs when one substance exists as large particles or when repulsion occurs between particles of the different substances; a homogeneous mixture occurs with small particles and attraction between them. A substance attracted to water is hydrophilic (hydro, "water"; philic, "seeking") but repelled is hydrophobic (phobic, "fearing").

Challenge:

Sand is a familiar substance with generally familiar properties (or are they?) Yes, it is a solid, but when added to water, does it become wet? Check out "magic" sand. In what ways is it and regular sand the same and different?

Time: 30 to 60 minutes

Procedure:

Introduction: Encourage team observation, comparison, investigation, and data recording at EACH of the three stations. (Wait until the wrap-up discussion to explain the lesson.)

1. Note how the sand flows while pouring some into the small dish so everyone can see, touch, and smell.

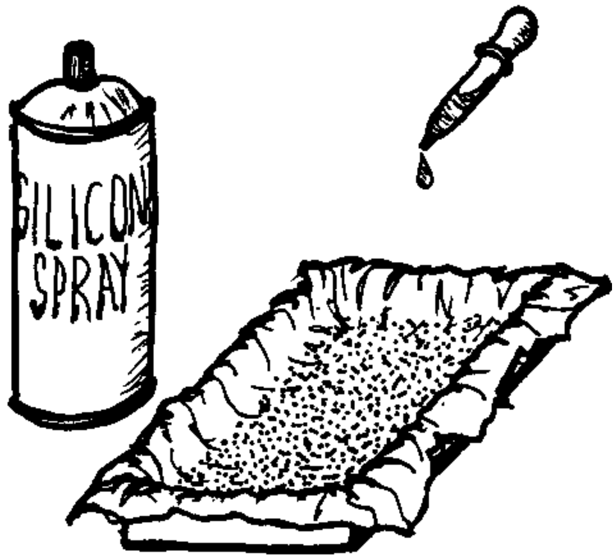
2. Use an eyedropper to put a drop of water onto a spoonful of sand.

3. Pour some sand into the pop beaker half-filled with water. Students should move the sand with spoons, utensils, and funnel. Then spoon some of the sand out of the water, put it on newspaper, then feel it again.

Wrap-up: On the blackboard write "Station":#1, :"Station" #2, and "Station"#3, discuss and record student observations. Make certain the 3 types of sand are compared, both dry and in

water. (Because regular sand is hydrophilic on its surface, it is "wetted" by water. The hydrophobic surface coating on magic sand prevents it from being "wetted", so the sand remains dry.

Clean-up: To save the sand, rubber band a coffee filter or paper towel over the soda pop beaker opening and pour off as much water from the sand as possible. Put each filter in a pan to allow the sand to dry, then store each dry sand in its container.



Further Challenges:

•Spray half a piece of cloth (or newspaper) with silicone spray and allow it to dry. Predict what will happen if water is dropped on the sprayed cloth. Compare the behavior of drops of water on treated and untreated halves.
•Do a long term study of each "magic" sand in water to investigate whether or not they will stay hydrophobic.
•Spread various hydrophobic powders on the surface of water. After you push your hand through the powder, it pulls out dry!

Connections:

Language arts: Write a fantasy story about the many uses of magic sand.

References:

Addison, Anthony. Editor. (1986). *The Children's Book of Questions and Answers.* London: Berkely Publishers Limited.
Matter, Life Science Library. (1965). New York: Stonehenge Book.
Walpole, Brenda. (1988). *175 Science Experiments to Amuse and Amaze Your Friends.* New York: Random House.
Sarquis, Mickey and Jarry Sarquis. (1992). Fun With Chemistry: *A Guidebook of Chemistry Activities for All Grades.* Madison, WI: Institute for Chemical Education, University of Wisconsin.

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39 Rainbow Glasses

By: Rebecca L. Bergeron

Focus:
Scientists use the properties of both waves and particles to explain the behavior of light. Light that appears to be one color may actually be made up of other colors. This is demonstrated when sunlight passes through a prism or acetate film diffraction grating. The spectrum formed from sunlight includes the colors of red, orange, yellow, green, blue, indigo and violet. By analyzing the light from stars, scientists can determine what elements are present in these stars.

Challenge:
Students will view light from various sources using their RAINBOW GLASSES. Can sunlight be separated into its component colors? Do different light sources produce different colors and combinations of colors.

Time: 45 - 60 minutes to construct glasses and do initial investigation.

Materials:
Each student will need:
acetate film diffraction grating, two 1" x 1" squares
poster board or oak tag for glasses frames
transparent tape
scissors
colored pencils, crayons, or markers
Each Class will need:
bare, incandescent 60 - 75 watt bulb and electrical socket
candle and matches
frame patterns
Optional:
induction coil and element spectrum tubes
spectroscopes
neon light
powdered element samples
distilled water
nichrome loops
acid for cleaning loops
bunsen or alcohol burner

Resources:
RAINBOW GLASSES can be purchased already assembled in most toy and novelty stores.

Safety Notes:
Remind students to NOT look directly at the sun through Rainbow glasses! Be sure to use caution reminders when using candles and open flames.

Advance preparation:
Make several glass frame patterns from oak tag or cardboard.

Procedure:
1. Have students make their rainbow glasses.
•Trace glass frame outline onto colored poster board, oak tag, or manila folders and cut out. Put name on frames. (Optional: decorate frames using markers, sequins, glitter, etc.)
•Attach acetate diffraction grating to backside of eye opening on frame using transparent tape. Use care when handling diffraction gratings as body oils, etc. can destroy their transmission properties.

2. Have students look through the diffraction grating at the natural light coming through the classroom windows.

3. Have students draw the spectrum they see using colored pencils, crayons, or markers and label this drawing "natural light". Check the order of color placement.

4. Turn on a bare 60 -75 watt light bulb. Have students look through the diffraction grating at this light source and draw the spectrum they see, label it "incandescent light."

5. Set up a candle, light it. Repeat step #4. Label this drawing "candle light."

6. Compare the three spectra and the color placement. Display students' spectrum drawings.

7. (Optional) Set up an induction coil and various element spectrum tubes. View this light through the RAINBOW GLASSES and spectroscope. Compare the results and spectra.

8. Students should take glasses home and report back after they have viewed different lights through the glasses (TV, strings of decorative lights, neon advertising signs, car lights, etc.). Discuss in class.

Further Challenges:

•Set up a lab activity or demonstration to show the colors of various elements when they are heated in aflame. Dip nichrome loop in distilled water and then in a powdered element: heat in flame. Clean loop in acid between samples. Use RAINBOW GLASSES and spectroscopes to look at burning elements. Compare results and spectra.

•Create a mnemonic to help students remember spectrum colors in proper sequence—red, orange, yellow, blue, green, violet. Example: Redness Occurred Yesterday, Better Get Vitamins.

References:

Allison, Linda and Katz, David. (1983). *Gee, Wiz: How to Mix Art and Sience or The Art of Thinking Scientifically.* New York: Little Brown and Co.

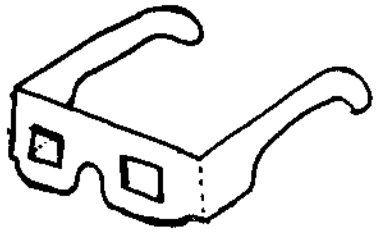
Williamson, Samuel J. and Cummings, Herman Z. (1983). *Light and Color in Nature.* New York: John Wiley & Sons.

Q Does light intensity affect the spectrum?

Q Do RAINBOW GLASSES work on cloudy days? At night?

Q Put on two pair of RAINBOW GLASSES. Look through the doubled up diffraction gratings: does this change the transmission of color?

Q What other types of spectra can you find in other light?



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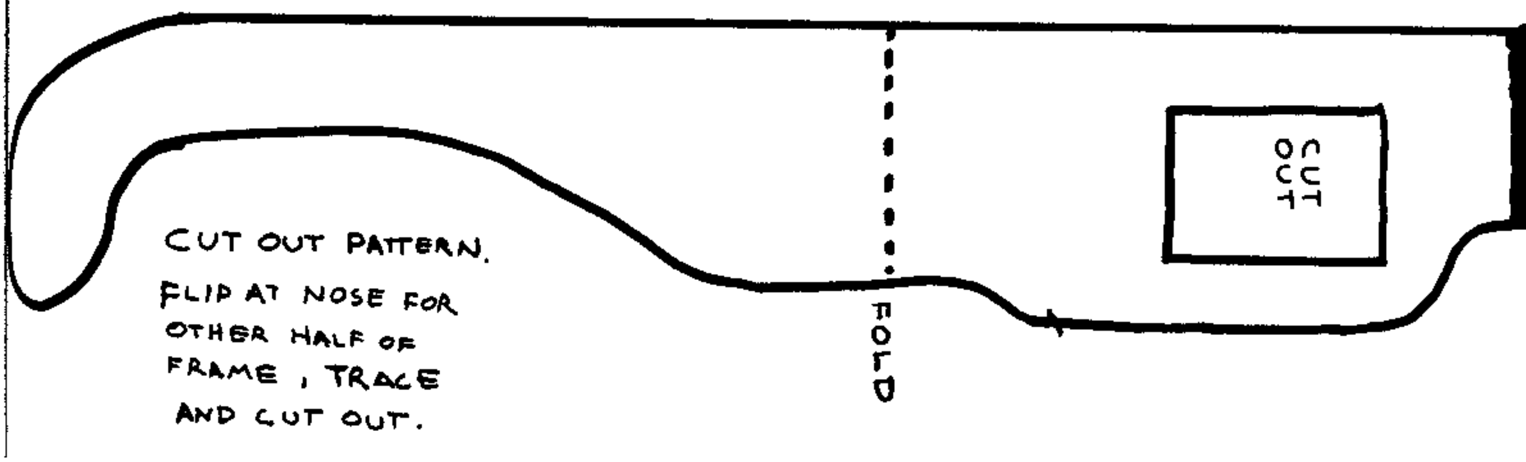

•Measure or estimate 1Tbs. of vinegar into each cup and mix thoroughly. Instant rubber!
•Squeeze the rubber under water in the sink or the tub to remove any extra latex or vinegar. Pat dry. Bounce, press, and pull the balls!

4. The balls may be taken home in plastic sandwich bags at the end of the class.

Q What will happen when the vinegar is added? Watch carefully. The reaction happens quickly!

Q What changes did you observe when the vinegar was added?

Assessment:

Ask the students to draw or write out the sequence of mixing the chemicals and ask them to describe what they observe.

Further Challenges:

•Set-up an experiment to find the average height of the bounce of the balls. Identify variables to make a "fair test".
•Use an encyclopedia or the library to research other products that can be harvested from a living rainforest, such as brazil nuts, wicker, rattan, allspice, chicle and some perfumes

Connections:

History: Make maple syrup or visit a sugaring house to look at a way that people in North America harvest a product from a living tree. (Please note: Maple syrup is made from the sap of the maple tree, not from the resin as is the case in the rubber tree.)
Research skills: Our supply of latex was effected during World War II. This led to artificial rubber research. Have students conduct library research on the topic.

References:

Tropics: Rubber. *3-2-1 Contact* Video. New York: Children's Television Workshop. #401.
Rainforests: Tropical Treasurers. *Ranger Rick's Nature Scope.* (1989). Washington DC: National Wildlife Federation.

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41 Styrofoam Gliders and Propulsion Planes

By: Gerald Wm. Foster and Anne Marie Fries

Focus:

Airplanes are able to fly because of unequal air pressure that is created when they move through the air. The air pressure is greater underneath the wings of the plane than on the top. As the air moves around the wings, it moves faster over the top; creating less air pressure than below the wings.

Materials and Equipment:

One styrofoam meat tray or foam board (approximately 8 1/2 x 11 inches) per student. However, assorted sizes should be available for the challenge section.
Glider pattern (Figure 1)
Large and small paper clips.
Scissors and/or xacto™ knives

Resources:

NASA Educational Affairs Division
400 Maryland Avenue, SW
Washington, DC 20546

Safety Notes:

Remind students not to throw a glider at another person. Establish a designated area for throwing gliders and rules as to how many can throw them at one time. It is suggested that students take turns when launching a glider when either throwing it or launching it with a device.

Q What do you think will happen if the wing were made shorter? wider? narrower? longer?

Challenge:

Using the basic shape what changes can you make to fly a glider the furthest distance? stay up the longest?

Time: 40 - 60 minutes

Procedure:

1. Have students construct their gliders.
•Trace glider pattern (figures 1 and 2) onto the meat tray.
•Cut out the wings and body.
•Bend the elevator up along dotted line and squeeze it firmly against the wing and then release.
•Press body into wing slot and twist the small tabs to lock body to the wing.
•Slide paper clips onto the nose tip of the glider. The glider is now ready to fly.

2. Establish a launching area either in the room or outside. Mark a spot on the floor or ground where a student must stand to launch the airplane. Make another spot which is approximately 25 meters away as the distance at which students must throw their gliders.

3. Students can explore factors such as weight, wing, and elevator positions and their effects upon the flight of the glider.

4. Encourage students to try different wing designs. Make them narrower, wider, shorter, or longer. Fold the wing tips up or down.

Assessment: Student will explain what change(s) were made to the glider and how those changes affected how long it stayed in the air or how far the glider went through the air.

Further Challenges:

•Use different materials for the airplane such as cardboard, construction paper, and regular paper.

•Set up a hoola hoop perpendicular to the floor as a circle for the gliders to fly through. The hoola hoop can be suspended by string from the ceiling or anchored by taping it with masking tape between two chairs.

•Invent a launching device using such things as a rubber band.

Q What alterations have to be made to make the plane do loops?

Q How many loops can the plane make?

Connections:

Mathematics: Measure how far the glider will travel or how many seconds and/or minutes it will stay in the air.

Keep track of the weight of each design to see if weight affects how the plane flies.

Reading: Read about the development of airplanes.

Research and read books about gliders to find out their actual sizes and how a person is able to fly them.

Research skills: Read about new innovations in airplanes and gliders that will save on the cost of fuel.

Check the Guinness Book of World Records to find out what kind of records gliders have set.

Reference:

Botermans, Jack. (1984). *Paper Flight.* New York: Holt, Rinehart and Winston.

Hosking, Wayne. (1987). *Flights of Imagination.* Washington DC: National Science Teachers Association.

Radford, Don. (1981). *Science, Models, and Toys: Science 5/13.* Milwaukee, WI:Macdonald Raintree, Inc. 69-83.

Weiss, Stephen. (1984). *Wings and Things.* New York: St. Martin's Press.

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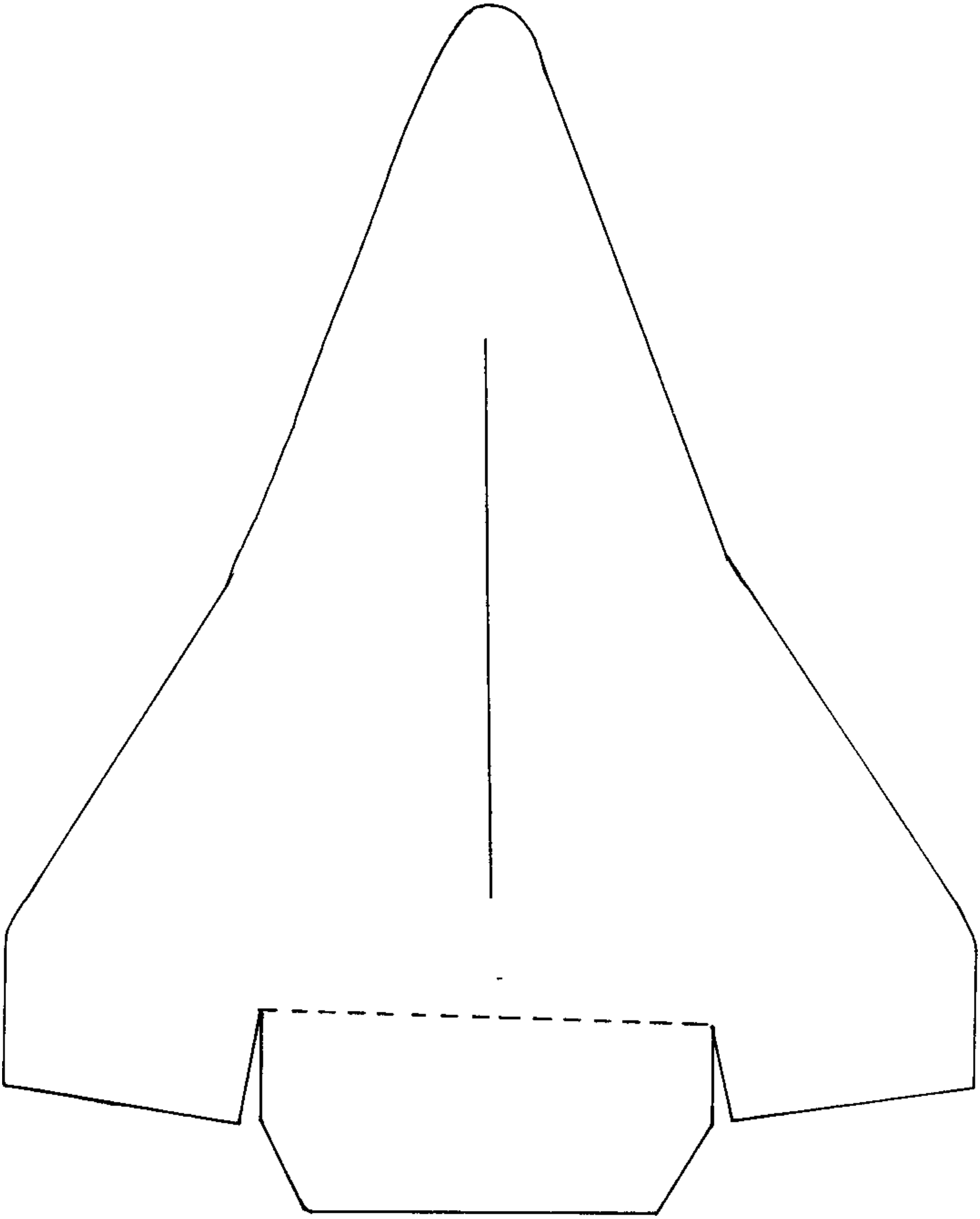

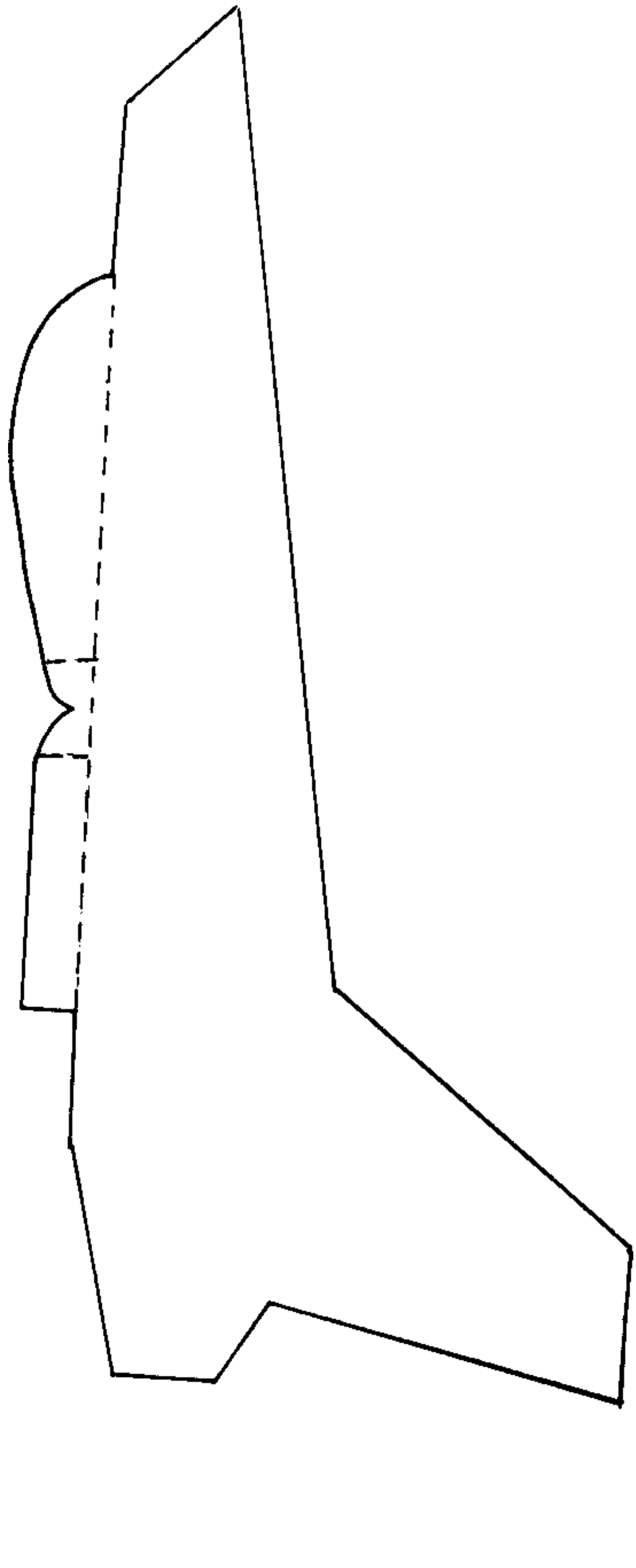

42 Twisting and Turning Clothespins

By: Gerald Wm. Foster and Anne Marie Fries

Materials:
Each child will need:
two old fashioned, non spring, wooden clothespins
(thick magic markers can be substituted for the clothes pins)
thick rubber band
two different colored markers or crayons.

Q What do you think will happen when you release the clothes pins?

Focus:
Children can explore the release of energy by a rubber band that untwists. This activity leads children to understand the differences between potential and kinetic energy. When two clothespins are twisted together energy is transferred to the rubber band. The rubber band hold potential energy until the clothespins are released which then becomes kinetic energy. The tension (potential energy) of the rubber band can be felt as long as the clothespins are held in the twisted position. The kinetic energy can be "seen" when the clothespins are released. The two clothespins twist and turn as the rubber band unwinds. During this activity children can make predictions and study the concept of probability. In other words, which clothespin will end up on the top?

Challenge:
Can you control which clothespin will end up on top after turning the clothespins several times?

Time: 20 -30 minutes

Procedure:
1. Instruct the children to color the top of each of their clothespins a different color. They can be creative and create faces for each clothespin.

2. Explain how to make the clothespin system by showing students the process.
•Wrap one end of the thick rubber band once around one of the two clothespins pulling it through itself.
• Insert the second clothespin through the loop that has been created and twist them together. If the rubber band is too long to securely hold the clothespins together, try shortening it by starting with the rubber band folded in half.
•Twist the two clothespins a given number of times, hold them together without releasing them, and lay them down side by side on a flat surface or floor.

3. Before releasing the clothespin system, have children predict which clothespin will end up on the top. Have children

do several trials keeping the same number of twists, predicting which one will end up on top. Ask them to make a chart of their predictions and the actual outcomes.

Q Where is each clothespin located before you release the system?

4. Ask children to infer the cause of a particular clothespin ending up on top. Have children figure out a way to control which one will end up on top of the other one.

Wrap-up: How do the number of twists affect which clothespin will end up on top? Where is the potential energy stored? How do you increase the potential energy?

Assessment: Students should show evidence of observation, controlling variables, keeping accurate records, and prediction.

Further Challenges:

•Try different sizes of rubber bands. Does the size of the rubber band affect how the clothespins unwind?
•Try different surfaces. Does the surface affect how the clothespins unwind?
•Try substituting other objects for the clothespins. Do objects such as pencils, nails, and straws work as well as clothespins? What is the effect of using objects of different shapes?

Reference:

Caney, Steven. (1972). *Steven Caney's Toy Book*. New York: Workman Press.

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43 Classroom Robo-Car Rally

By: Jan Woerner

Materials:
Apple II series or an IBM
LEGO™ TC logo Dacta™ Starter Kit with software and construction kit or a Dacta™Technic I Kit, Technic II Kit, or Technic Control I Technology Pack (or similar hardware and software from another vendor)
data disks
student journals for keeping records
inclined plane

Resources:
LEGO™ TC logo Teacher's Guide. LEGO Dacta Educational Products, 555 Taylor Road, Enfield, CT 06082-1989.

Focus:

LEGO™ TC logo is far more than materials and software - it is also an environment for discovery. This learning-rich environment incites invention and inquiry. Children need to be allowed to follow their own instincts. Teachers must balance between too much structure (thus stifling spontaneous learning) and imposing too little structure (thus fostering chaos).
LEGO™ TC logo is a construction set; it is a programming language; it is a science activity; it is a math activity. LEGO™ TC logo is a project-oriented activity.
In this activity, student-designed and constructed cars will be investigated. A motor will be connected to the rear axle so that when the motor turns, the axle turns, and the car moves. If the pulley on the motor is smaller than the pulley on the axle, then the axle turns more slowly than the motor, but with greater force.
Gears can be added to make the car faster or slower. A gear is a wheel with teeth around the outside. Two or more gears are used to transfer force, change rotational speed, or change rotational direction. Gears and gear trains help build a mechanical advantage. A gear with 8 teeth can be used to drive one with 16 teeth to get twice as much force - but it will only move at one-half of the speed. If a gear with more teeth is used to turn a gear with few teeth, the motor will turn faster but with less strength.

Challenge:

What factors affect how fast and how far a car goes? Does the number of wheels affect the car's speed or distance or how much weight it will carry? Does the weight or shape affect the speed or distance? Can you use a motor to make the car go? How can you make the motorized car go faster?

Time: LEGO™ TC logo is a long-term activity which will involve students for many weeks or months.

Procedure:

Classroom Organization: LEGO™ TC logo is both an individual and a collaborative group activity. It is difficult to use with one computer, one interface box, and one construction

kit. Several kits allow students to build more projects and still use the same interface card and box. Several hardware stations allow students to program and test their machines when they are ready.
The inclined plane needs to be set up in the room so that when the car exits the plane, it has a long smooth surface on which to run. This "track" can be anywhere in the classroom. The motorized cars need a smooth flat surface also. This surface needs to be in the vicinity of the computer. The total distance that the car can be from the back of the computer is about 2.5 meters. The cords which connect the interface box to the motor are only that long.

Introduction: Although many kinds of machines are possible with the LEGO™ TC logo Starter Pack, this activity will discuss the construction of cars with the LEGO™ bricks. A good introduction for students is to challenge students to build a vehicle with LEGO™ bricks which will roll down an inclined plane. Students, working individually or in teams, need some time to design and build these vehicles. Sketches which show many possibilities will stimulate student construction, and any design that can be constructed from the kit should be allowed. Students should discuss their designs with each other, keeping records of their ideas, plans, and successes in their journal. They should determine what factors affect how far the car goes once it is off the plane and on the flat. Encourage students to record their hypotheses on what makes the car go further. The students should discuss what data would need to be collected to answer this question. They also should discuss what force is making the car move. This activity can be revisited every day or two, or at a regular time each day. It may take several days for students to construct a car which will go down the inclined plane. These cars need to be tested and retested in order to determine the factors which affect how far and how fast the car goes.

Q Why is it important to repeat tests?

Development of Activity:

1. After discussing the non-motorized vehicles, challenge students to build a "car" of LEGO™ bricks which is motorized. Examples of several "standard" cars is provided in the kit. Students will use the "small-to-big" connection between the motor and the axle. Again encourage many different designs and encourage students to keep good records in their journals.

2. Introduce the students to the computer interface hardware and software. Since the cars are programmed with Logo, students who have experience with that language will have

little difficulty with the control. Students who are new to the programming language, will find a few commands are all they will need to get their car running. The commands and programs they write should be recorded in their "inventor's notebook" along with their plans for their vehicles.

Safety Notes:
Water and other liquids must be kept away from the computer and the interface box. The cords connecting the box and the car need to be neatly secured and kept out of the way of the car's wheels. The track for the car needs to be out of the main classroom traffic patterns so students don't trip over cars or cords.

3. Plug one of the motors directly into the control box, and show students what happens to the motor with the various commands. Students can investigate for themselves and learn to program the few commands they will need.

4. Students construct their vehicles, hook a motor to their axle, program the computer, and get their vehicle to "run." The "Getting Started" booklet provides some hints for finding problems with the car or with the program. Once several students have working models, others will follow quickly.

5. The kit can be used to build a model showing how to use one gear to turn another. This turning can be done by hand. A partial model of the car with the motor and axle only can be plugged into the interface box in order to watch the action of the two together.

6. Challenge students to enter their vehicle in a Classroom Robo-Car Rally. Make up several categories so many students can "win." Categories could include speed (including the slowest, continually moving vehicle), the heaviest, the lightest, the most unusual etc. Provide time for students to build, rebuild, test, and retest their vehicles. Students could be encouraged to pull loads with their vehicles, thus investigating how to use gears for strength rather than speed.

7. The kit provides optosensors and touch sensors as well as traffic lights. All of these can be programmed to provide additional challenges in the Rally.

Wrap-up: The day of the Rally would provide a closure for this activity, but also will challenge students to continue with other LEGO™ TC logo projects. Arrange the categories to provide success for all students. The design and decoration of the Rally course can be aided by student designs using other parts of the kit. Students should know what challenges will face them in the Rally so they can prepare their vehicle and their programs.

Assessment:

Student projects need to be evaluated on the process and

progress of their work, not on the results. The student's level of involvement and invention are a better indicator of learning than the finished product. Students should be evaluated for both individual and collaborative work, and on their reflection upon the meaning of the things which happen as they test their vehicles.

Further Challenges:

The Starter Pack has all kinds of bricks, plates, wheels, pulleys, beams, gears, worm gears etc. Students can construct a Merry-Go-Round, a washing machine, a tractor, a conveyor belt, and other robots. The materials in the pack can be set up to provide an in-depth study of gears and gear ratios, and worm gears can be investigated to see how they change side-ways rotations into forward rotation. The optosensors and touch sensors provide ways of turning on lights and making the robots appear "interactive." The other kits provide many additional machines for students to build.

Connections:

Mathematics and science: in measurement, averaging, graphing, time-rate studies, and logic.
Social Studies: topics on invention, inventors, the history of transportation and machines, and the use of machines in our lives is a logical connection to this activity.
Technology: Compare the gears used in this project and bicycle gears.

References:

LEGO™ TC logo Teacher's Guide. Enfield, CT: LEGO Dacta Educational Products.

The Author

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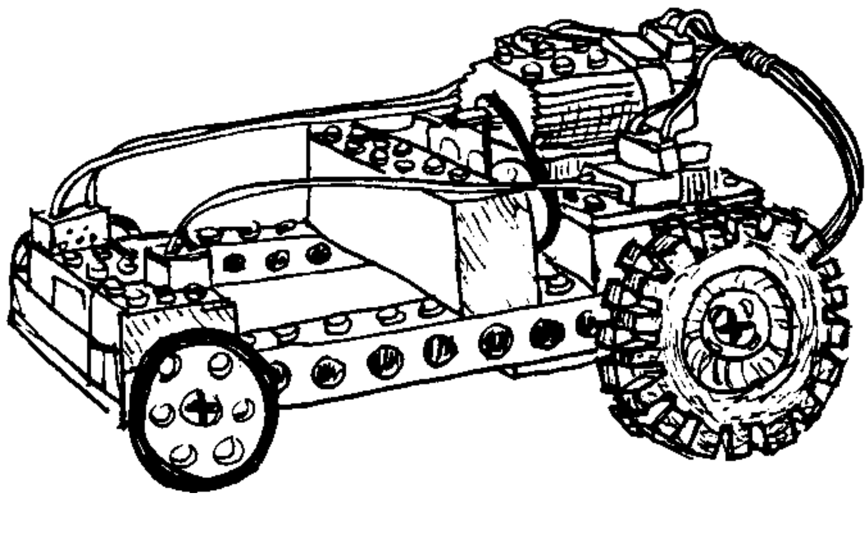
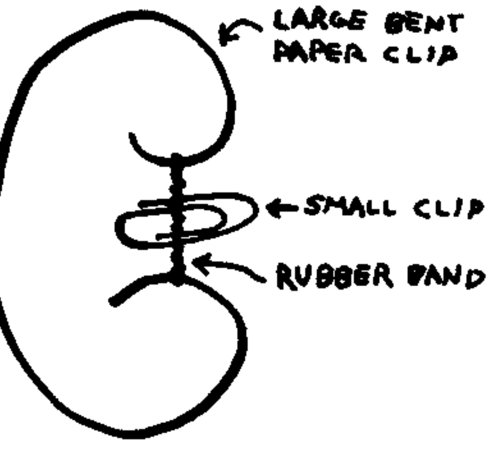


44 Rattlesnake Eggs

By: Marlene Gregor and Larry Cwik

Materials:
large and small paper clips
various-sized rubber bands
various-sized letter and coin envelopes
suggested variables: small washers, buttons, small jewelry boxes

Safety Notes:
Be careful not to poke your finger when bending the paper clip. The ends can be sharp. Set rules about using rubber bands before distribution of materials. Discuss the danger of being hit with a rubber band.



THE DEVICE

Focus:

This simply-constructed "toy": demonstrates kinetic and potential energy; produces sound vibrations; and promotes interest in rattlesnake facts. By fastening a paper clip to a tightly twisted rubber band, the simulated sound of a "rattler" is produced when the clip strikes the inside of an envelope, usually giving the envelope-opener a surprise. In order to create the vibrations, the device uses both potential and kinetic energy. Since potential energy is stored energy (energy that is ready to be set into motion), a rubber band is stretched on a wire frame (a large bent paper clip.) More potential energy is created by inserting a small paper clip into the stretched rubber band and twisting the clip around until the band is taut (cocked.) When the grasp of the paper clip is released, the clip spins around, releasing its stored energy. This is kinetic energy, the energy of motion. As the spinning clip repeatedly strikes the sides of the opened envelope, a rat-a-tat-tat noise is made, much like that of a rattlesnake. Variables can be introduced by experimenting with materials of different sizes and masses, because changing the mass and speed will change the amount of kinetic energy. Also, different sound intensities can be made inside the envelope by these variables. To further understand the joke, it is important to know that rattlesnakes do not lay eggs. Unlike most reptiles, they bear their young alive.

Challenge:

Can you demonstrate potential and kinetic energy by constructing the given model and making it work? By changing variables (paper clips, washers, buttons, rubber bands and containers) can you make a better model?

Time: one to two class periods of 40-60 minutes

Procedure:

Introduction: Present an envelope to the class that is marked, "DANGER! RATTLESNAKE EGGS! OPEN WITH CARE!" telling a fictitious story about how the eggs where obtained. Ask a student to open the envelope. After the joke is revealed, the class is invited to make a model.

45 Doppler Bee

By: Wayne Snyder

Materials:

Each student will need:
Doppler Bee pattern
40 cm piece of string
(2) 1.5 cm pieces of plastic or rubber tubing
popsicle stick or tongue depressor
scissors
stapler
thick rubber band

Advance Preparation:

•Copy the Doppler Bee pattern on the stiffest paper that the copier can use. If no copier is available that can handle stiff paper, copy the pattern and glue onto file folders.
•The popsicle sticks or tongue depressors may be pre-cut to the length of the bee pattern. Tin snips work well.
•Pieces of plastic or rubber tubing can be cut with scissors and should be about 1.5 cm long. Split each piece of tubing length wise so they will be able to fit over the popsicle sticks.
•Gather up thick rubber bands. Those that come around celery in the supermarket or are around bundled mail are excellent. Thin rubber bands will not work.

Safety Note:

Be sure that students stand far enough apart that they do not hit each other (intentionally or unintentionally) as they swing their bees around in circles. Remind students to be cautious with rubber bands.

Focus:

Producing Sound: In order to make a wave, you need some type of vibration. You can make water waves by dipping your finger up and down. You can make waves on a rope by jerking the rope from side to side. Since sound is a wave, we may guess that to make a sound we need a vibrating object. Sometimes the vibrations can be seen, such as the vibration of a guitar string. Other times the vibrations are not so visible, such as the sound made by a flute. Many insects create sound by their rapidly moving wings. For example, the bee creates a buzzing sound with its wings.
The Doppler Effect: Have you ever noticed the pitch of a train whistle as the train comes toward you? As a sound approaches you, the pitch you hear will get higher. This is called the Doppler Effect. As the train is moving towards you, the waves are being crowed closer together, making the frequency, or pitch, higher. As the train moves away from you, the pitch you hear will get lower. The waves behind the train are being spread apart making the frequency lower.The faster the object is moving, the more the frequency will change. Police radar often works on the principle of the Doppler Effect.

Challenge:

How does the pitch of a sound change as the source moves towards you or away from you?

Time: 30-60 minutes, depending on how much the teacher prepares in advance and depending on the age and dexterity of the students.

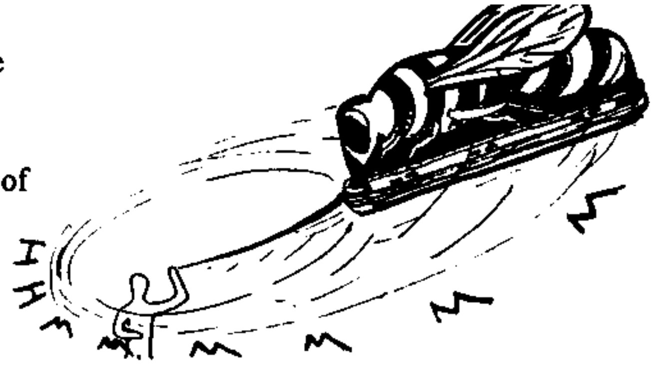
Procedure:

Introduction: This activity is not meant to be an introduction to sound. Before making and using Doppler bees, the students should be familiar with properties of sound, such as "what causes sound" and "what causes pitch".

1. Instruct students in how to make a Doppler Bee.
•Cut out the outline of your Doppler Bee. (fig. 1)
•Lay the popsicle stick along the base of the bee and cut the

stick off at each end so that it is square at each end and is the same length as the base of the bee.
•Staple the stick to the bee.
•Place a piece of split plastic or rubber tubing over each end of the popsiclestick.
•Staple the string firmly to the front portion of the popsicle stick. Tie a knot so that the string will not come off the staple.
•Stretch a rubber band around the popsicle stick so that it is supported by the tubing pieces.

2. Students are now ready to test the Doppler Bee. It's best to go out of doors where there is sufficient room to seperate students. Demonstrate the procedure -- grasp the end of the string and swing your bee around in circles. Allow students to investigate.



Q What is vibrating?

Q From where you are standing in the middle of the swinging bee, does the pitch or frequency sound like it is changing or staying the same?

Q Try swinging it at different speeds. Do you hear different "resonant" frequencies at different speeds?

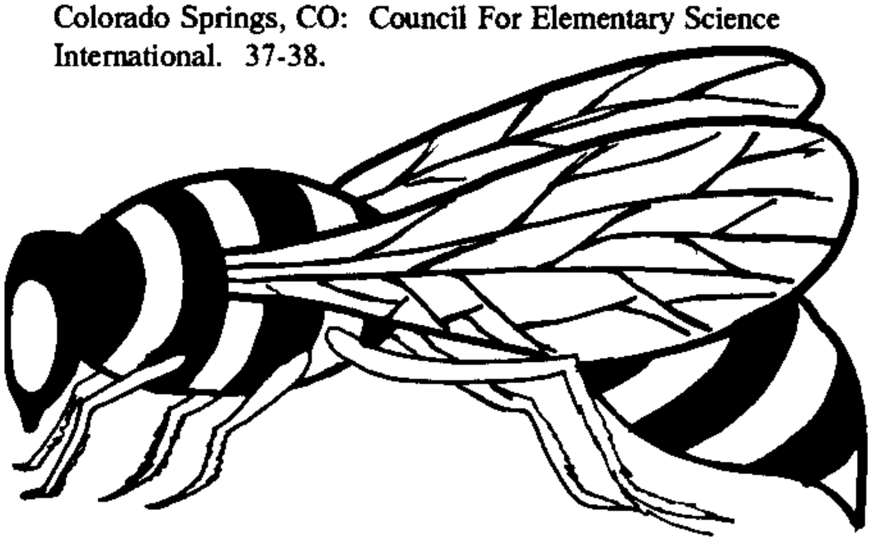
Q Now have someone else swing the Doppler Bee in a circle while you stand to the side. Do you notice any difference in the pitch of the sound as it swings?

Q When the Bee is approaching you, does the pitch appear higher or lower?

Further Challenges:
• Cut pieces of hose from a swimming pool filter to different lengths. Swing the lengths around your head. Notice the Doppler Effect. Notice the relationship between the lengths of the hose and the resulting pitches.
•Illustrate what you think the waves of sound might look like as they move away from the bee and toward observers.

Connections:
Life science: Find out more about insects, classification, bee social structure, making honey, and pollination.
Music: Constructing musical instruments based on information learned about sound.

Reference:
Malone, Mark. (ed). 1992). *CESI File Sheets Volume 2.* Colorado Springs, CO: Council For Elementary Science International. 37-38.



The Author
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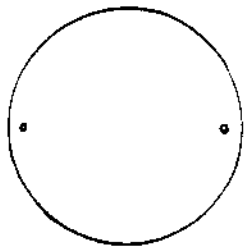
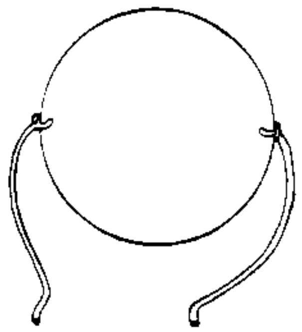
46 The Thaumatrope

By: Brian K. Nelson

Materials:
piece of cardboard
thaumatrope images
scissors
string (tightly wound)
glue
single hole punch can be helpful

Advance preparation:
Photocopy the pictures (below) to be used for initial thaumatropes.





Q What do you see when the card spins?

Q How can you explain what you see when the card spins?

Focus:
In 1826, the English physician J. A. Paris invented what may have been the first cinematographic device—the Taumatrope. The Thaumatrope consists of two different pictures on opposite sides of a piece of cardboard and when spun rapidly these pictures appear to merge into one. The Thaumatrope's optical illusion of one picturefrom two pictures is similar to motion pictures in which several images shown quickly in succession and viewed by the eye give the appearance of motion. Both of these illusions are attributed to the phenomenon known as persistence of vision. Images projected onto the retina of a human eye can remain unchanged for a period of one-tenth to one-twentieth of a second. These fractions of a second are time enough for more than one image to be superimposed on the retina, thus giving the illusion of multiple images merging into one or appearing to move.

Challenge:
Student will construct a thaumatrope. What makes the Thaumatrope illusion possible?

Time: one class period of 40-60 minutes

Procedure:
1. Instruct students on how to construct a thaumatrope.
•Cut a circle of 3" in diameter out of the cardboard for circular patterns or cut a piece 2.5" x 3.75" for rectangular patterns.
•Cut out pictures (as reproduced) and glue them onto opposite sides of the cardboard circle. Make sure that the pictures are aligned and inverted from each other so that the pictures merge when spun.
•Punch two holes on opposite sides near the edge of the piece of cardboard.
•Tie a 3" piece of tightly wound string through each hole.

2. Have students investigate their thaumatrope. Show them how to hold the strings between their fingers and spin the card. Discuss their observations.

Further Challenges:

• To demonstrate student understanding of the concepts involved have them create their own thaumatropes. Students can draw their own "merging" pictures by using designs and logos.

•Reinforce the concept of persistence of vision by having students make a flip book.

Q Can a thaumatrope be made in another shape?

Q What is the largest thaumatrope you can make? the smallest?

Connections:

Social Studies: Children of early American settlers made many toys based on persistence of vision. Find out more about these toys, make models, and demonstrate to the class. Be sure to explain the science of these toys.

Reference:

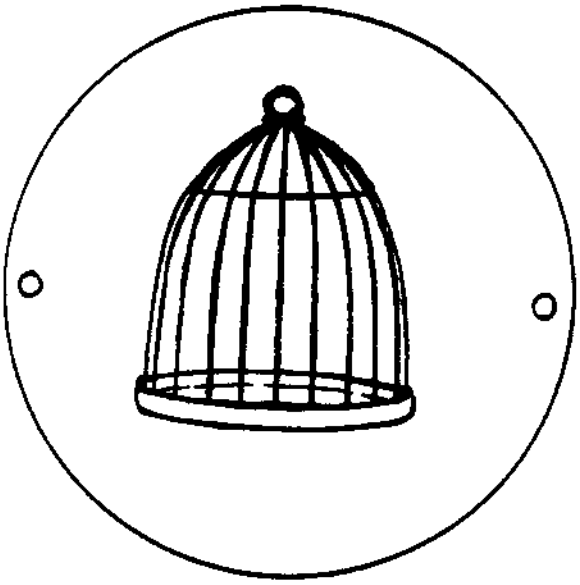
Caney, Steven. (1972). *Steven Caney's Toy Book.* New York: Workman Press.

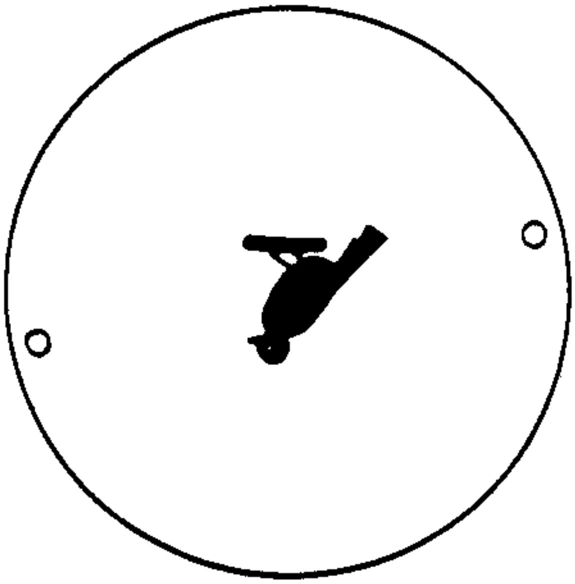
Malone, Mark. (1987). *CESI Sourcebook V: Physical Science Activities for Elementary and Middle School.* Columbus, OH: ERIC Clearinghouse for Science Mathematics, and Environmental Education. 42-50.

Provenzo, E.F. and A.B. Provenzo. (1979). *Easy to Make Old-Fashioned Toys.* New York: Dover Press.

The Author

Brian K. Nelson teaches at Pulaski Middle School in New Britain, CT. He is a frequent presenter at state conferences.





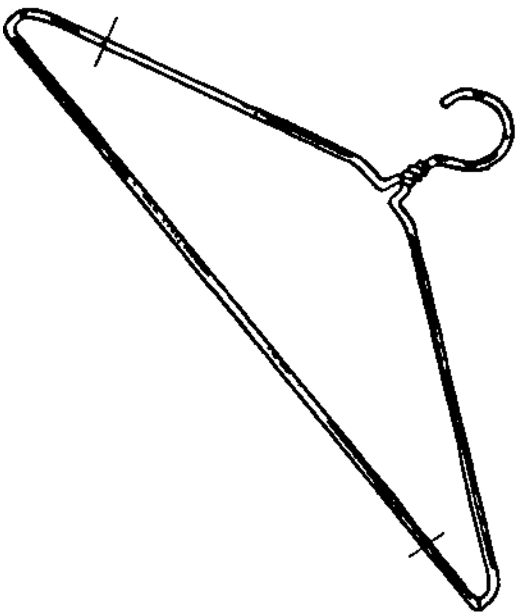
47 The Skyhook

By: Brian K. Nelson

Materials and Equipment:
wire hanger
sheet of oak tag or a file folder
copy of sky hook figure
scissors-type pliers
felt tip markers, crayons, or colored pencils for coloring the skyhook (see pattern on next page)
belt

Advance preparation:
Copy the skyhook pattern onto oak tag paper either:
•directly by use of a copy machine.
•indirectly by use of a ditto machine
•by copying onto standard weight paper and then gluing the copy onto oak tag or a file folder.
You may want to precut coat hanger wire.

Safety Note:
Caution students concerning the cut wire, it may have sharp ends.



Focus:
The skyhook is one of a number of traditional folk toys that rely on the center of gravity to produce an illusion of a seemingly impossible balancing act. The center of gravity typically lies in the center of each toy figure with a piece of wire acting as both the point of balance and the counterweight.

Challenge:
Students will use a wire hanger to make two toys that will demonstrate the center of gravity of an object. Can you locate the center of gravity of each skyhook?

Time: One to two class periods.

Procedure:
1. Explain how to make the skyhook:
•Color the skyhook pattern.
•Cut out the pattern
•Fold on dotted line and punch a hole through the circle located at the bottom of the boat.
•With a pair of pliers, cut off a length of wire from the coat hanger as illustrated.
•Gently bend the wire as shown to the left.
•Punch the hooked end (short end) of the hanger through the hole at the bottom of the boat making sure that you punch through the uncolored side.
• Fold the two colored sides around the hooked end of the hanger and tape them together.

2. Ask students to investigate the toy and determine how it can be balanced.

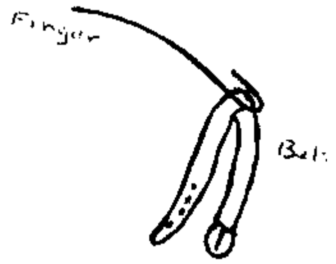
3. Lead students to understand that they can set the skyhook on the edge of a table or desk and adjust the boat and/or bend the hanger as needed until it is balanced. They can also try balancing the skyhook on the end of their finger or on the end of a pencil eraser. Set it rocking and enjoy the illusion.

Further Challenges:

- Experiment with the balance point and counterweight adjustments and measure the effects on the center of gravity.
- Create your own skyhook patterns—animals are popular subjects.
- Recycle the remaining hanger by making another variation of the skyhook.
- With a wire cutter or a pair of pliers cut off a straight piece of hanger approximately 4.5 to 5.5 inches in length.
- Using a pair of pliers bend the wire to the shape in the diagram to the right.
- Place a belt in the hooked end and place the opposite end on your finger.
- Adjust the skyhook by bending the wire or shortening the handle to provide for the best balance. Try this skyhook with and without the belt.

Q Where is the balancing point?

Q Where is the center of gravity located?



Q Why is the belt needed?

Q Where is the center of balance?

References:

Provenzo, E.F. and A.B. Provenzo. (1979). *Easy to Make Old-Fashioned Toys.* New York: Dover Press. 13-17.

Schancke, D. (1992). *American Folk Toys.* Chelsea, MI: Bookcrafters.

Allison, Linda and Katz, David. (1983). *Gee, Wiz!: How To Mix Art and Science.* New York: Little, Brown and Company. 101-106.

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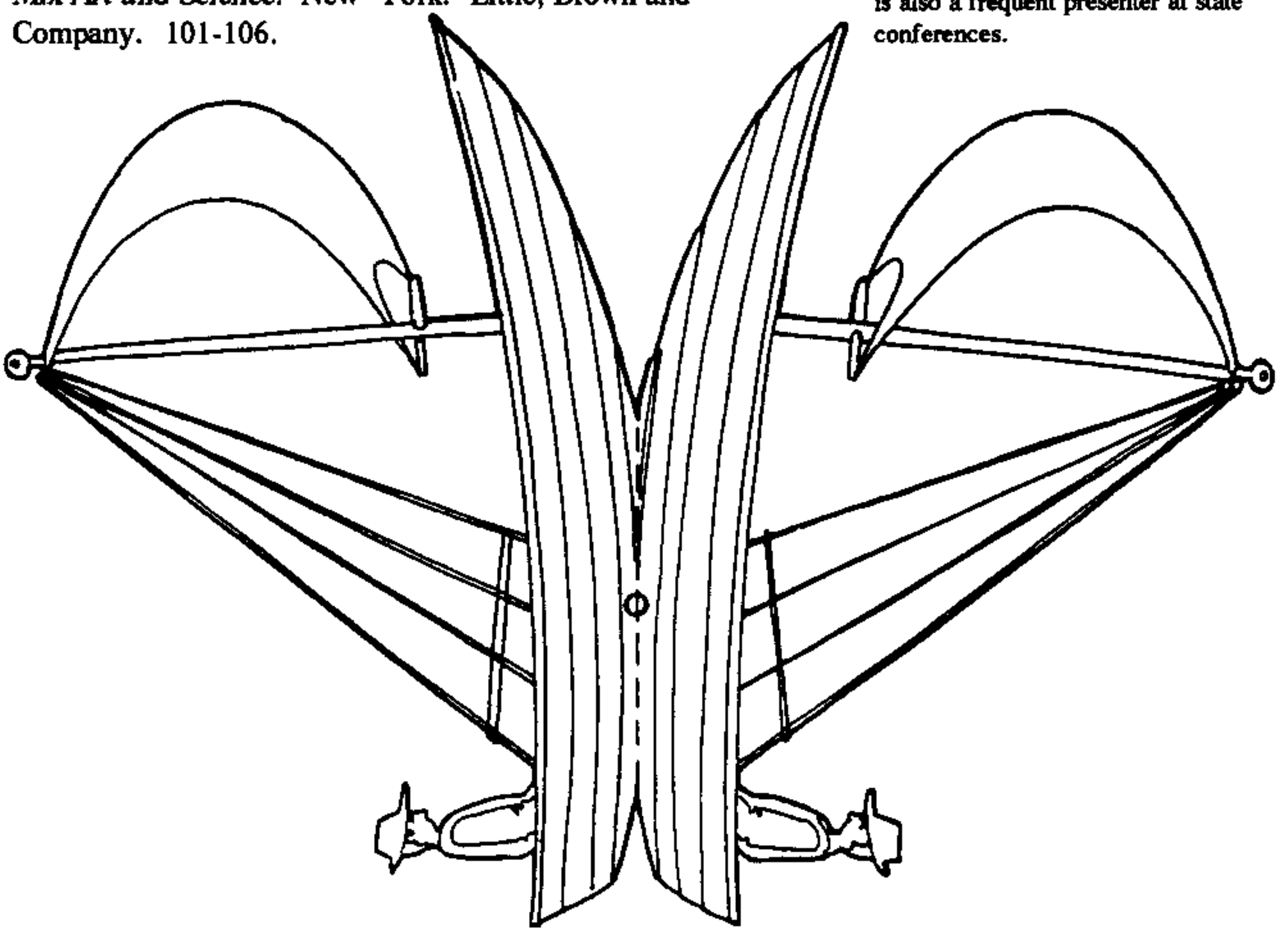


48 Hairy Harry

By: Suzanne Williams

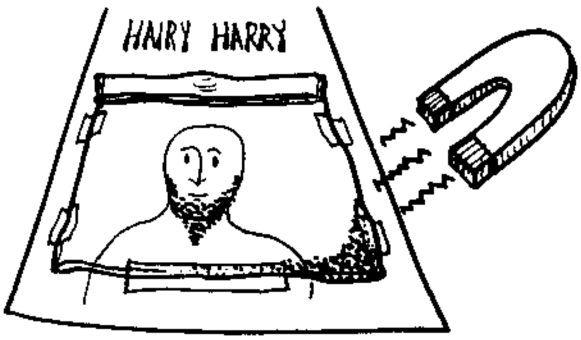
Materials:

For each student:
oak tag (about 6" x 9" for each student)
zip-close baggies
tape
iron filings (any scientific supply house)
magnets
crayons or markers
Light weight materials such as tissue, paper, fabric, file cards, etc.
paper clips

Advance Preparation:

Iron filings can be messy and difficult to remove from magnets. Place magnets in sandwich size zip-close bags for easy clean up.

Q How many paper clips can you move with your magnet at one time - without touching the magnet to the paper clips?



Q Will kitchen magnets work on Harry Hairy?

Focus:

Magnets attract iron and steel. This pull or force, also called magnetic attraction, can be seen and demonstrated. Magnetic force travels through air and most light weight materials like paper, plastic and water. The strength of the magnet can be tested by placing these objects between a magnet and other objects.

Challenge: Try to move a paper clip with a magnet without touching the paper clip to the magnet! Use a magnet to cover a face with "hair".

Time: 30 - 40 minutes

Procedure:

1. Provide students with light weight materials, paper clips and magnets. Ask them to try to move a paper clip with a magnet without touching the paper clip to the magnet.

2. Show a model of "Hairy Harry" and ask how iron filings can be used to make hair, beards or mustaches on the bald face.

3. Hand out oak tag and ask students to draw a funny face with crayons or markers in the middle of the paper. The drawing should be about the size of a plastic bag. While the students are drawing, hand out zip-close bags, sprinkle about 1 teaspoon of iron filings into each bag, and zip it shut.

4. Have students position the plastic bag over the face and firmly tape it in place on all sides (see illustration).

5. Play with the toy! Allow the children to share their creations with each other.

6. Ask students to test their iron filings and magnets on other materials. Through what other materials will the force of the magnet move iron filings?

7. Allow the children to take their toy home and use their own kitchen magnets to make it work.

Further Challenges:

•Try making simple mazes or maps on paper or oak tag and move iron filings along the maze or map.
•Pull paper clips up the side of a glass cup filled with water.

Connections:

Mathematics: Collect a variety of magnets and measure their relative strengths, use paper clips or nails as the unit of measure and record the number of clips or nails that each magnet can lift. Graph the results.

References:

"A First Look at Electricity and Magnetism". (1990). Washington DC: National Geographic Society Filmstrips.
Mandell, M. (1968). *Physics Experiments with Children.* New York: Dover Publications.

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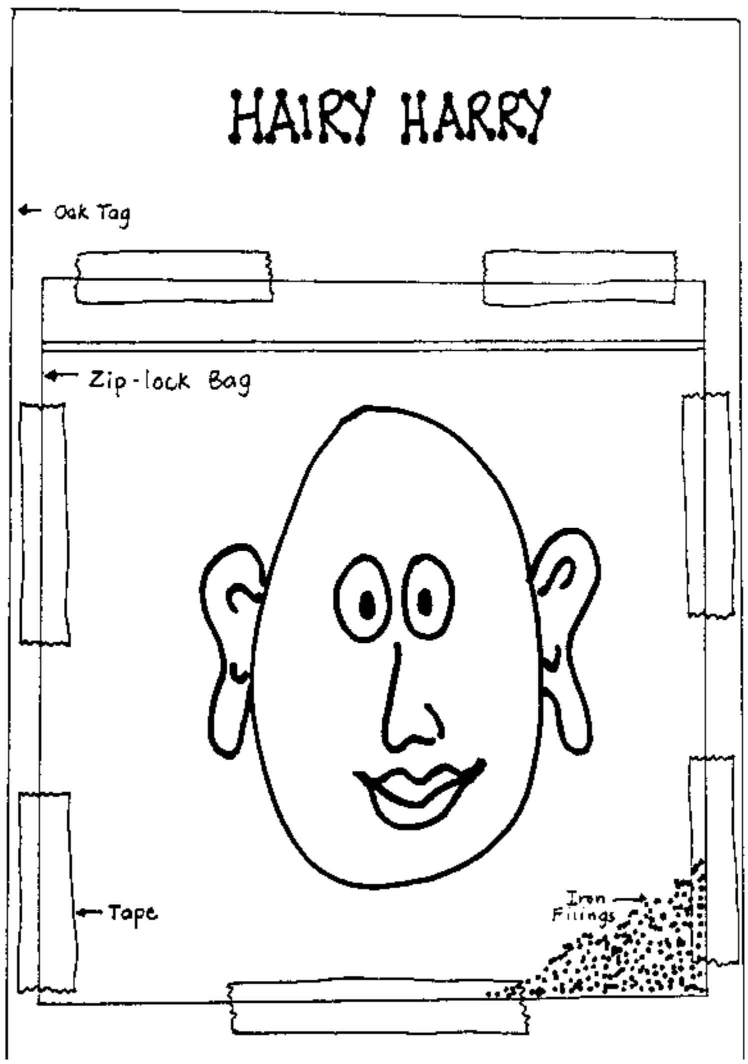


49 Levitation: Gravity Versus the Electric Force

By: Beverley A. P. Taylor

Focus:

Electrically charged objects exert forces on one another. All materials contain both positive and negative charge. Normally, they have the same amount of each, so they have no net charge. In the rubbing process, negative charges are transferred from the foam to the rod and the ring. No charge is created; it is merely moved from one object to another.

As the ring floats, there are two forces on it: its weight downward and the electrical force exerted by the rod upward. (Since the ring and rod have the same charge, they repel.) The electrical force gets larger as the ring and rod get closer together. The ring will hover at the distance above the rod that makes the upward electrical force exactly cancel out the downward force of gravity. Thus, heavier rings will float lower than lighter ones.

Materials:

Tools:
scissors
transparent tape
hot glue gun
Per apparatus:
45 cm section of 1/2 in. PCV pipe
sheet of 3/8 in. foam cut into a 25X40 cm piece and a 10X15 cm piece
cork to fit the end of the pipe
toothpick or cotton swab with one end cut off
2.5X 50 cm strip of 1/32 in. polyethylene packaging material
Note: The dimensions above do not need to be exact
Cost: Assuming several are made, material should be about $1 per apparatus.

Safety Note:

If students use the glue guns, be very cautious about burns. Conduct this activity in a large space to prevent students from poking one another accidently.

Advance Preparation:

Cut PCV pipe with a power saw or hacksaw. Other materials preparations can be done by teacher in advance or by students in class. Foam pieces must be cut and the small one glued into a cylinder. Wrap the foam loosely around the rod and put a bead of hot glue on the overlap line. Hold until cool then cut away the excess.

Challenge:

Students will build a static electricity toy (originally sold as "Mystic" by Knots, Inc. but no longer available). It looks like magic, but understanding how it works turns it into science. Can you explain how the ring can float in mid-air with no visible means of support?

Time: 30 to 45 minutes depending on how much material preparation is done prior to class.

Procedure:

1. Review with the students the concept of static electricity recalling everyday examples.

2. Have students complete an assembly of apparatus by forming the polyethylene strip into a ring using transparent tape to attach the ends, placing the foam cylinder on the pipe, inserting the cork into one end of the pipe, and inserting the toothpick into the cork. (Plus any steps not completed by the teacher.)

3. Demonstrate a sample apparatus. Agree on names for the various parts, such as, rod, slide, ring and mat. Carefully review procedure of using the apparatus. (Or handout written

instruction.)

a. Lay the ring flat on the mat.

b. Charge the rod by rubbing the slide up and down about a dozen times.

c. Keeping the slide on the rod. Rub the slide across the ring several times. Turn the ring over and repeat the rubbing.

d. Refresh the charge on the rod by rubbing it with the slide again leaving the slide at the end of the rod near your hand.

e. Using the toothpick or swab, toss the ring into the air. Move the rod underneath the ring to keep the ring in the air.

5. Explain that they will be using the apparatus in pairs (or small groups). They should experiment for a while, then discuss the different forces that are involved as the toy works. If time and materials allow, they may try shapes other than a ring.

Wrap-up: Have the students report on their discussions of the forces. Clarify their ideas if necessary.

Q Does the number of times the ring is rubbed affect how high it floats

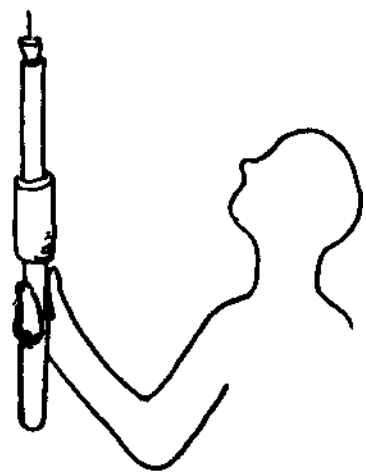
Q Why do you have to keep moving the rod to keep the ring in the air?

Q Add some extra transparent tape or stickers to your ring. Does this change the height at which it floats?

Further Challenges:

•Hold contests to see who can keep their ring in the air for the longest time. Then, investigate whether the size of the ring affects this maximum time.

•Have teams develop a strategy to keep the ring in the air during a relay race, then conduct the race. This requires an understanding of the concepts involved in the levitation and "what will happen if" thinking.



Connections:

Social Studies: Discuss uses of materials for a purpose other than their intended one (such as, the PCV pipe and packaging material) and connect this to reusing and recycling products.

Language Arts: Students may write an imaginative story or play about a creature which depends on electrical forces to allow it to fly above the Earth, then act it out with the toy.

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The Author

Beverley Taylor is a member of the physics faculty at Miami University (Ohio) and Co-director "Teaching Sience with Toys", a teacher inservice program.

50 Balancing Figure

By: Gerald Wm. Foster and Anne Marie Fries

Materials:
several patterns
for each student:
1 5X8 unlined index card
crayons
scissors
masking tape
2 pennies or weights
pencil

Advance preparation:
Make several patterns for student group use.

Q On what point of the figure does it balance?

Q On what point of the figure does it balance with the additional mass added?

Q What else can you get the figure to balance on besides your finger and the pencil eraser?

Focus:
An object will balance when resting on its center of gravity. The center of gravity is the point where its weight is equally distributed around it, and consequently gravity is pulling equally on all sides. As a result, the object balances upon this point. By changing the distribution of weight, the center of gravity also changes and therefore the point upon which the object will balance changes.

Challenge:
How many ways can you find to balance a figure?

Time: one class period of 40-60 minutes

Procedure:
1. Place students in groups of three or four. Provide each group with materials to trace the figure onto index cards, cut it out, and decorate as desired.

2. Challenge students to try to balance the cardboard figure on their finger or the eraser end of a pencil. Explain that the point at which the figure balances is the center of gravity.

3. Next have students attach, with masking tape, a penny to each hand of the figure. Ask them to try to balance it with the additional mass.

4. Have each member of the group attach the pennies to different locations on their figure. Ask them to discuss and predict the center of gravity in each case. Finally, have them test and record their data.

5. Provide time for each group to report their findings to the entire class.

Assessment:
Have students explain how this toy works.

Further Challenges:

•Explore what happens when you use two weights that are not equal in mass.

•Use small, flat cardboard boxes such as those that are used for jewelry purchases and tape two coins inside. Tape boxes shut. Explore the boxes and try to balance them and determine where the center of gravity is located.

•Create mobiles out of dowel rods. Cut out figures and use assorted objects to balance each rod.

Connections:

Physical education: Ask the Physical education teacher to join the class and discuss balance in gymnastics.

Occupations: Identify jobs that require balance (both human sense of balance and the balancing of objects).

Geography: Cut out a map of your state and find the center of gravity. Is that spot the center of your state? Why or why not?

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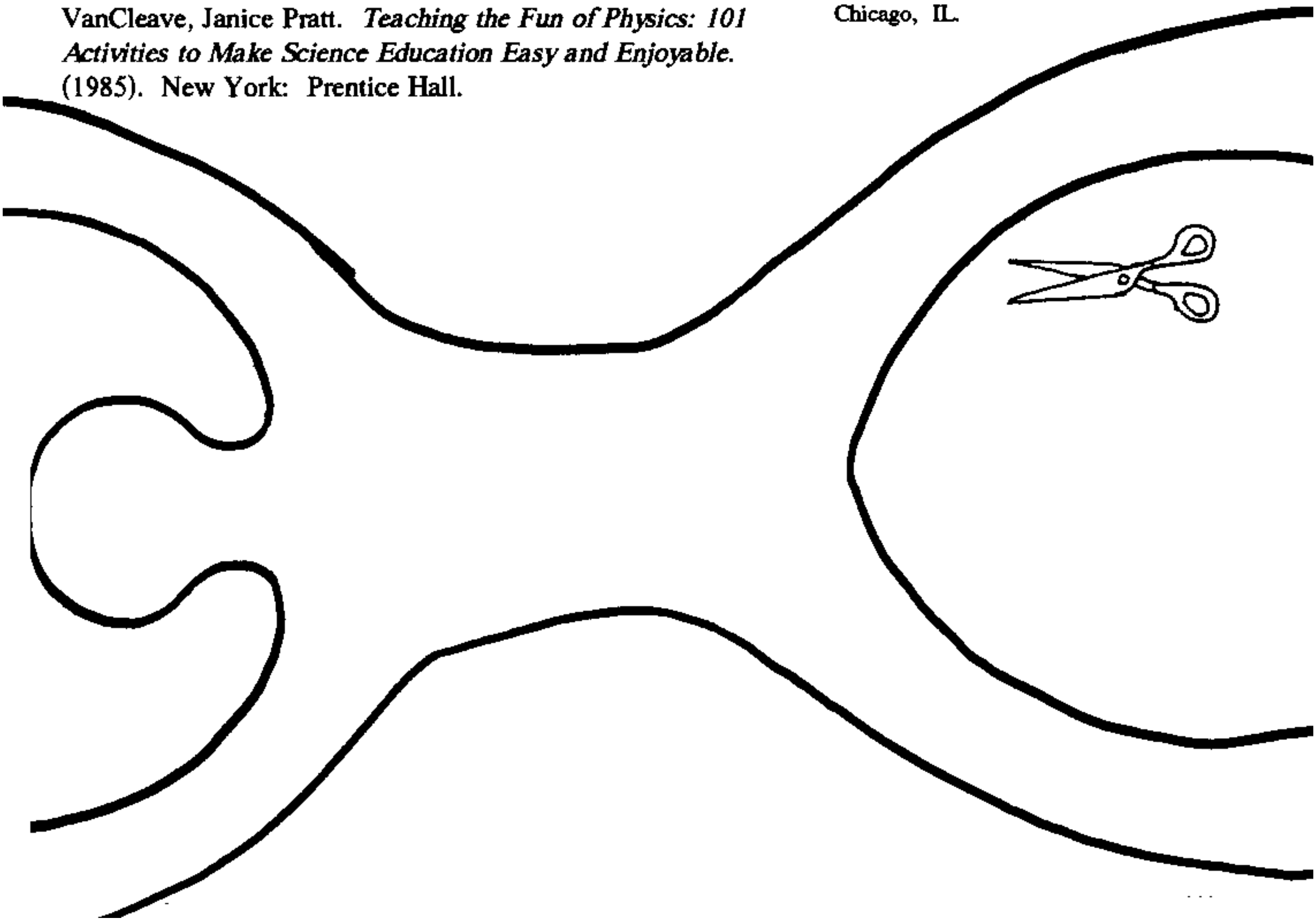


51 Energy Storage In A Mechanical Mouse

By: Kevin D. Finson

Materials:
Each group of two to four students will need:
hammer
nail
masking tape
meterstick (flexible is best)
sheet of graph paper
mechanical mouse-
- paper towel tube
- 2 baby food jars
- rubber band
- metal washer
- pencil or dowel rod
- paper clip

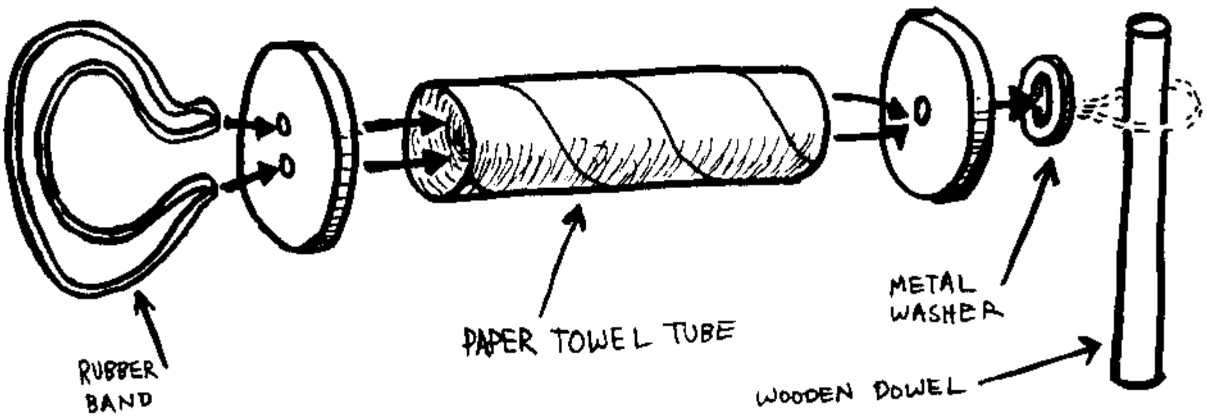
Focus:
The two types of energy, potential and kinetic, can be studied in a slightly indirect manner through this activity. Potential energy can be stored in a wound-up rubber band and later be released as kinetic energy when the rubber band unwinds. The unwinding rubber band results in the movement of a device similar to the age-old spool-and-pencil toy — the "mechanical mouse." This toy can also be used to illustrate the limitations of mechanical systems (ie - when the rubber band breaks).

Challenge: How much potential energy can a rubber band store? How much kinetic energy can a rubber band provide the mechanical mouse? From a graph of the number of windings of a rubber band and the distance the mechanical mouse travels, can you predict the distance the mechanical mouse will travel with other numbers of turns? Can you identify different variables that may cause the mechanical mouse to behave in different ways?

Time: 30-45 minutes

Procedure:
1. For the younger students, the teacher may wish to prepare the mechanical mice ahead of time. Older students can learn about constructing a mechanical system by building the mechanical mouse themselves if the teacher desires. Construction of the device is as follows:
Lay each baby food jar lid on the floor or table. Using the hammer and nail, punch two holes in one jar lid as shown in Figure 1 and one hole in the center of the remaining jar lid. Once the holes have been punched in each lid, use the hammer to flatten out the jagged edges around the holes. Take the two-hole jar lid and insert one end of the rubber band through one hole, then insert the other rubberband end through the other hole. Next, straighten out the paper clip but leave one end bent so it can serve as a hook (make this narrow enough to fit

through the nail holes in the baby food jar lids.) Hook both ends of the rubber band to the hook end of the paper clip. Pull the paper clip and rubber band through the paper towel tube, then through the one hole in the second jar lid, then through the center of the metal washer. You will need to stretch the rubber band to accomplish this. While still stretching the rubber band, insert the pencil or dowel rod through the two end loops of the rubber band so that approximately 4 centimeters extend past the rubber band. Then carefully remove the paper clip hook. Using masking tape, tape the jar lids to the paper towel tube — you may wish to use small cardboard spacers to help keep the lids centered on the ends of the tube. If you wish to provided more traction for the mechanical mouse, wide rubber bands can be placed around the rims of the lids to serve as tires, or "mouse treads." Your mechanical mouse is now ready to go!



2. Have students carefully "prime" the mechanical mouse by winding the rubber band (turning the dowel rod) in the same direction. Students should wind the rubber band just enough that the device doesn't move when set on the floor, but will move if an additional turn of the rubber band is made.

3. Students should next turn the rubber band for 5 turns (in one direction), then place the mouse at a marked position on the floor and let it "run." You should forewarn students that the mouse is not likely to run in a straight line, and they should observe its path carefully so they can later measure the distance

Numer of turns	Distance traveled
5	
10	
15	
20	

Q How can you keep track of the path of the mouse?

Q What happened to the mechanical mouse when you wound its rubber band 5 turns and then released it on thefloor?

Q Why did you need to wind the rubber band to make the mouse work?

Q Where did the energy come from that was used to drive the mouse?

Q Once the rubber band was wound (before the mouse was released to run on the floor), what kind of energy did it possess?

Q Once the mouse was released, what kind of energy did it possess?

Q Did the mouse go twice as far with 10 turns as it did with 5 turns? Explain why it did or why it did not.

Q What happened to the amount of kinetic energy the mouse possessed as its amount of potential energy increased?

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the mouse travels along its path - not the distance from the starting point to the stopping point. Also, the dowel rod should be "dragged" behind the mouse as the mouse travels, not pushed in front of the mouse.

4. Students should measure the distance the mouse ran for each of the5 turns and record this in a table. This procedure should then be repeated for 10, 15, and 20 turns. (NOTE: rubber bands may break at 20 turns. This will be a good chance to discuss the limitations of mechanical systems. They can be overloaded - i. e. the amount of energy put into them is too great for the devices to accommodate, so system failure occurs). The number of windings of the rubber band is a relative measure of the amount of potential energy in the mouse. The distance the mouse travels is a relative measure of the kinetic energy released when the rubber band unwinds in the mouse.

5. Have students analyze their data and graph the number of turns versus the distance traveled. Using the graph, ask them to infer - if you could use a rubber band that would not break, what distance would the mouse travel if you wound its rubber band 40 turns?

Assessment:

The science concepts to be assessed include information concerning: kinetic energy (energy of motion) and potential energy (energy possessed by virtue of position or condition); an object possessing potential energy can have that energy converted into kinetic energy and vice versa. If students understand the concepts, they should be able to explain the energies and energy changes in a working yo-yo or other similar toys. A related concept is that we must put energy into a machine/system if we are to get performance out of the machine/system. In doing this , we may overload the system and cause it to fail.

Further Challenges:

•Try this activity using thinner or thicker rubber bands and determine if the thickness of the rubber band affects the potential and kinetic energies of the mouse.

•Try the activity on tile floor compared to carpeted floor. Does this affect the potential or kinetic energies of the mouse?

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Inventing Toys to Teach Science

52 Inventing Toys - Tips

By: William J. Boone

Focus:

Inventing in the classroom can provide a great brainstorming experience for students. There are a number of teaching tips and activities that can greatly add to a "toy invention convention" in your classroom.

Materials:
old toy parts
paper
pencil
tape
straws

Challenge:

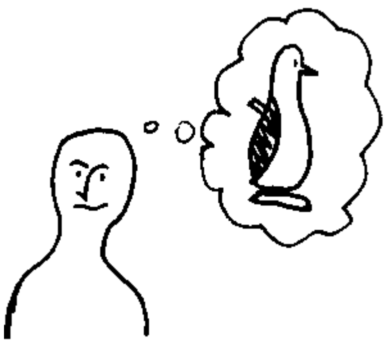
How can current topics from within and outside of school be incorporated into a toy? How can you use the resources of resale shops for inexpensive toy construction? Students will compare the types of toys available in the stores to the ones developed in a classroom.

Safety Note:
Caution students about utilizing toy parts for purposes other than those for which they were intended. Inappropriate use can lead to injury.

Time: as many class periods as you wish

Procedure:

Introduction: By incorporating a current topic from school, students can be given a starting point from which they can develop a science toy. If one just tells students to develop a toy- many will quickly become frustrated. By supplying students with a range of springboard topics for toy development, the activity will not only foster brainstorming, but it will cause students to review science concepts already discussed in class.



Q What science concepts could we use for the design of a toy?

Ask student groups to discuss what science concepts they could use in the development of toys. Ask students to look through their present science book to develop some toy topics. Also provide science textbooks used by students during the grade. Some "prime the pump" topics suggested by students include: magnets, color, light, friction, energy, waves.

Q Can you develop a blueprint of your toy?

1. After students have developed a few toy themes, ask them to start creating their toys. Fancy materials are not needed -- often tape, string, paper, and straws can be used to develop enjoyable and educational toys. Ask students to sketch their toy on paper, this will help them think clearly about their creation. Scientific engineers draw a plan of their projects.

2. In addition to providing inexpensive multipurpose construction materials, provide parts from old toys for display

and inclusion in new toys! By visiting resale shops, seeking parent donations, and carefully selecting supplies, a collection of materials can be gathered for a toy invention activity.

3. After students have drawn their "blueprint" ask them to start constructing their toy. This activity becomes an "in" and "out" of class activity and students can add any sort of material that they wish to their toys. (see safety note)

4. After the toys have been constructed by students, request that the "science" behind each toy be explored and explained. Have each student demonstrate their toy to the class with a full explanation of the science involved in making the toy function.

5. At the conclusion of presentations, ask the class to consider other science concepts that each toy might demonstrate.

Q Scientists need to make educated guesses. Can you guess the past use of the toy parts I have brought to class?

Q What is the science behind your toy?

Further Challenges:

•Bring in your favorite toy. When the toy is displayed have the class discuss the science concept they believe is being demonstrated.
•How might you design and make an inexpensive version of your favorite toy?
•Ask students in your cooperative group to critique your work and suggest ways in which your toy could be improved.
•Evaluate the structural strengths and weaknesses of your toy. Why must the toy be strong at particular points?

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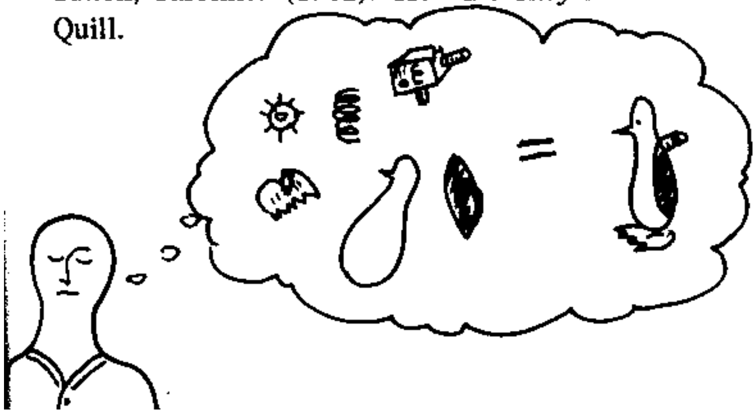

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53 Stepping into Design with Bendable Toys

By: Marilyn L. Fowler

Focus:

Students classify objects into natural, processed, synthetic, recyclable and non-recyclable groups, then test for properties of flexibility. They also examine and group objects by recyclability, including plastic containers. After exploring with these concepts and their interpretations, students design and make a toy that can bend and is made of three different materials, at least one recyclable.

There are many classes of material; some of those classes are natural, processed, synthetic, recyclable and non-recyclable. Natural materials generally are recycled by wearing-down processes (erosion). The minerals that make up natural materials are returned to nature and eventually used in other materials. For example, the carbon in wood returns to the soil and may make its way into new plants.

Processed materials are those which have natural origins but have undergone some change in a factory or other place where people work. Plywood, for example, is make of wood, a natural material, but it is layered and glued for strength in assembly or processing. Many processed materials can also be eroded by weathering in nature and return to the soil as minerals.

Synthetic materials, in contrast, are entirely fabricated by people in laboratories, and are not recycled by natural wearing down processes. The plastic milk jug can remain in a landfill for years and years, simply breaking down into smaller bits of milk jug; the minerals, the petrochemicals used in its manufacture, will not return to the soil.

Materials can be grouped by their properties. Some materials are flexible, or elastic, and some are not. Elasticity is the property of being able to bend back and forth without being damaged. Materials that are elastic will return to their original shape after bending or other loads are applied.

Challenge:

Make a toy that can bend and is made of at least three different materials. At least one of the materials must be recyclable.

Time: approximately 180 minutes

Materials:

yarn
cloth scraps
set of plastic containers with recycling numerals on bottom scissors
paint or markers

set of objects to test for flexibility including:
wooden items
metal items
plastic items

recycled materials from "junk center" including:
plastic liter bottles
empty cereal boxes
other containers

fasteners:
brads
staplers
tape
adhesives

Advance preparation: Set up the recycled materials in one area of the room.

Safety Notes:

Caution students about cutting and utilizing recycled materials. Extra care should always be taken when using materials for purposes other than for which they were originally intended.

Procedure:

Introduction: Invite the students to visit the "junk center" and look through the materials to become familiar with them. Ask students to look around them and find some ways that the things in the room can be grouped.

1. Start a list of groups they name, such as "machines, books, tools, furniture" and begin asking students what the things are made of. Talk about the materials they see, and ask them to name some more materials that things are made of. You should have several of the following classes of materials in your list: wood, paper, glass, cloth, metal, aluminum, etc.

2. Write the word "synthetic" on a chart. Find out if some know that synthetic means made by people. Do some know the opposite word, for something made by nature? (Natural). Also write the word "processed": on a chart and explain the meaning.

3. Start a new chart, "Natural", "Processed" and "Synthetic", and have the students place or write the objects they had previously listed on the Natural, Processed, or Synthetic list.

4. Help students place the items on the correct list according to the material in each object. Develop a rule with the students that something natural is usually wood, or bits of stone or clay, or raw fibers such as linen, wool or cotton. Tell the students that most materials have been processed, such as textiles, metals, and glass, and that some things made synthetically include plastics, nylon, rayon acetate, and most modern rubber.

Q How would you classify something that has natural, processed, and synthetic parts?

5. When students have placed items on a list, begin another chart, asking students what the headings "Recyclable" and "Non-recyclable" mean. (The definition may have much to do with your community and what materials are collected for recycling there.) Show children the recycling number on the bottom of some plastic containers such a margarine tub or yogurt cups (see illustration). Tell them that this number places the plastic in a special group for recycling.

Q How can people in our community recycle?

Q Why should we recycle?

6. Hold up one of the plastic containers that has flexible sides. Ask students if they know of any materials that can bend like the plastic does. Talk about the forces that push and pull on things, and try to find some things around the room that do and some that do not bend.

Q Why do people want some things to bend?

Q What are some things that do bend, and why do they bend?

7. Ask students to imagine what a toy might look like that could bend, and why it would bend. A bending toy might be a doll that could move its legs, or a clown whose ears would flap, for example. Let the students think of their own examples.

8. Show children the following Design Brief, which is a challenging task to be accomplished in teams:

Make a toy that can bend and is made of at least three different materials. At least one of the materials must be recyclable.

9. Tell the students that they must first ask questions about the task, and wait until everyone has had a chance to think of questions that will clarify the challenge.

10. Form the students into teams of two, and ask them to talk to their partner about toys they might make. When they agree on a toy to make, they may go to the junk collection, select materials to use, and build their toy.

11. When teams have had a chance to make a toy that bends, have them share it with the class and ask questions such as those given below in "Assessment."

Wrap-up: Place each team's toys in a Design Gallery for others to see. Have them write or recite a short description of their toy and its name, as well as the process of teamwork and construction that went into its creation.

Assessment: Have the teams present their creations and ask answer questions. Also encourage the teams to question one another.

- Where does the toy bend?
- Of what three different materials is the toy made?
- Which material(s) in the toy are recyclable and which are not?
- Who did what jobs in the making of the toy?
- Did each person have an interesting job to do?
- What was the most difficult thing about making the toy?
- How did you overcome obstacles?

Connections:

Language arts: Analyze items and characters in literature that have properties of bending, and read about materials that make up everyday things.

Write creative stories about characters that can bend in extreme

ways, and the adventures they can have.
Similarly, make up characters like "the glass woman" or the "wooden dog" and invent tales about how such creatures would function in the world today.
Mathematics/science: Develop a way to determine how much one type of material bends in comparison with another. Find the material or object in your room that bends more than any other, using the method developed. Some materials are plastic in nature, that is, they are flexible to a certain point of force, after which they won't return to their original shape. Investigate which materials fit that description.
Art/Environment: Create collages made up of only non-recyclable or recyclable materials.
Social Studies/Culture - Research to find out how to recycle materials in your community, and take a field trip or interview a worker to investigate the kinds of materials most often recycled and which materials people recycle least.
Research skills: Conduct primary and secondary research to determine what recycled milk containers become after reprocessing.

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